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Making a Difference: Prioritizing Equity and Access in CSCL

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Making a Difference: Prioritizing Equity and Access in CSCL

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Preface

Drexel University and The University of Pennsylvania are co-hosting the 12th International Conference on Computer Supported Collaborative Learning from June 18 to June 22, 2017. The CSCL conference has an explicit focus on how and why collaboration can enhance learning processes and outcomes. CSCL emerged in the late 1980's and early 1990's to bring together researchers from cognitive science, educational research, psychology, computer science, artificial intelligence, information sciences, anthropology, sociology, neurosciences, and other fields to study learning in a wide variety of formal and informal contexts (see http://www.isls.org for more details).

Before the establishment of the biannual CSCL conferences, there was a NATO-sponsored workshop in Maratea, Italy in 1989 and another workshop sponsored by Xerox PARC in 1991 at Southern Illinois University. The first international conference was held in 1995 at Indiana University, followed by meetings in Toronto, ON, Canada (1997); Maastricht, Netherlands (2001); Boulder, CO, USA, (2002); Bergen, Norway (2003), Taipei, Taiwan (2005); New Brunswick, NJ, USA (2007); Rhodes, Greece (2009); Hong Kong, China (2011); Madison, WI, USA (2013); Gothenberg, Sweden (2015). There is also a scholarly journal, the *International Journal of Computer-Supported Collaborative Learning*, and a book series published by Springer.

Submissions for CSCL 2017 were received in November 2016 and sent out for peer review. 386 paper and poster submissions were received from 28 countries, and the overall acceptance rate for submissions was 45%. We accepted 60% of symposium submissions, 35% of full papers, 31% of short papers, and 48% of posters. 295 experts completed 1287 reviews, and an additional 61 senior reviewers assigned papers to reviewers and provided summary reflections on each submission to guide the development of the program.

Making a Difference—Prioritizing Equity and Access in CSCL

CSCL 2017's theme, Making a Difference—Prioritizing Equity and Access in CSCL, revisits the concepts of equity and access to learning opportunities that have always been central to collaborative learning pedagogies and research. Work in the 1960s sought to address issues of classroom authority structures with group activities. Work in the 1980's and 1990's attempted to provide young people with access to safe, collaborative, after-school learning environments. Research on learning communities also empowered students to have agency over their learning processes and to see themselves as creators rather than merely consumers of knowledge. More recent work has sought to provide opportunities for a wider range of students through resident and online university courses, new collaborative learning technologies, and Massive Open Online Courses. Throughout this work, there have been two common themes that focus on equity and access: equity at a small, community scale and equity at a larger, societal level.

The most common theme in CSCL is the promotion of equity within the classroom community. Many researchers have emphasized the need to provide students with more agency over their own learning processes. Others have focused on breaking down social hierarchies that can interfere with important social learning processes. For example, work on communities of learners and learning forums has examined how students take on increasingly active roles in deciding what is learned and how. Some questions that emerge as part of this work include:

- How much and what kind of participation is equitable?
- How important is equitable participation for learning?
- How do we measure participation?
- How do emerging technologies and methods allow us to address and understand participation?
- How do we teach students to participate and encourage others to participate in a manner that allows equal opportunity and access to content learning and skill development for all learners?
- How do we distribute responsibility over learning across teachers and students such that all have opportunities to develop the ability to monitor, regulate, and make decisions about collaborative practices and learning outcomes?

Another common theme within CSCL is the promotion of educational equity and access on a broader scale. Namely, how collaborative learning can attract, support, and engage underrepresented groups while ensuring that all students have access to high-quality and productive cognitive and social learning contexts. Common questions that emerge as part of this work include:

- How do we design activities and tools that meet the needs of different populations?
- How do we balance required content learning with the development of necessary skills?
- How can we develop important collective thinking and discourse processes in ways that engage all learners?
- How do we narrow gaps in learning and educational access?
- How do we build partnerships with schools and communities to ensure that our designs are informed by multiple voices and sustainable beyond the span of a research grant or program?

The CSCL community has additional questions to ask since collaboration, in and of itself, can be a barrier to many students. This is particularly the case for students with physical or learning disabilities and socio-emotional problems. The special education community is underrepresented in the learning sciences. Addressing this absence would increase the richness and diversity of our community. Experts in special education could help us address design issues for students with a range of abilities and developmental needs and make CSCL more accessible to a larger population.

We should also evaluate our designs in the context of cultural, social, and technological change, identifying potential unintended consequences of technology use and ways that we can improve our work to develop the types of skills learners will need in the future. This means not only examining how our designs impact a particular learning outcome for a current population but to carefully consider their effects on related learning and socio-emotional processes and future populations.

Finally, an important consideration is how we can scale CSCL in ways that maintain essential principles of pedagogy and equity. As technology allows for more forms of interaction, we need to ensure that we go beyond providing access to collaborative activities and towards supporting the development of important learning processes within these environments. For example, the need to maintain social relationships between students and teachers is an important concern at a time when technology use, automation, and social isolation is rapidly growing.

Addressing these larger questions will ensure that the core principles and practices that are central to CSCL do not get lost as technologies and educational practices evolve and proliferate. Focusing on these questions can help us inform policy and provide access to higher quality, meaningful, collaborative learning environments for a broader population of students.

Our three keynote speakers are at the forefront of examining these broader questions. Dr. Laura Czerniewicz highlights the inequalities that exist in higher education and how we can redesign learning environments to mitigate inequalities. Dr. D. Fox Harrell examines the use of growing technologies and their impacts at the intersection of technology use, personal identity, and societal identity. Dr. Teo Chew Lee focuses on larger implementations in ways that maintain core CSCL principles and attend to important social relationships between teachers and students.

Many classic and returning research themes remain stable within these proceedings. Classic research themes include the examination of knowledge building practices and communities, using technology to disrupt traditional teaching practices, and examining discourse, feedback, and argumentation. Returning themes include an emphasis on regulation and awareness at the level of the group and many technologically supported methodological approaches to evaluate learning and social interaction. One of the fastest growing returning themes is learning analytics. This strand gained prominence in the CSCL community in 2015 and had an even stronger representation this year.

Additionally, this year's submissions showcase significant shifts in education and the growing influence of CSCL in some new domains. We noticed four growing trends in CSCL this year:

1. A continued increase in studies of CSCL in informal learning contexts.
2. A growing focus on supporting scientific modeling.
3. A larger representation of CSCL in higher education, especially in the information and computer sciences.
4. An increasing emphasis on scaling CSCL through the creation of massive online courses and large-scale assessments, as well as through community-level participatory and technology design.

Given these growing trends, it was not surprising to see many submissions that were taking the time to step back and assess the state of the field to examine important methodological and practical issues.

As we consider this year's submissions in light of the conference theme, the challenge is to continue holding the principles of equity and access at the forefront of our activities as we grow and expand as a field. Even with a call for papers that addressed the theme, representation for research examining equity and accessibility was relatively small. While there is much to address and embrace regarding the potential of new methods and technologies to advance our field, the values that drive our research should remain the same. We cannot risk losing sight of the reasons why we want to promote discourse as access to new technologies make discussion and collaboration more accessible and easy to evaluate. Otherwise, we run the risk of expanding the computer supported aspect of CSCL without supporting collaborative learning for all.

In these volumes, you will find a collection of thoughtful papers that examine collaborative learning at different levels of scale, question our current practices and assumptions about learning and assessment, and take innovative approaches to support learning both in and out of school. Many of the papers focus on these by addressing issues of equity and accessibility within the classroom community and a few take on the challenge of addressing our theme at a broader scale.

We end by acknowledging the contributions of the many members of our community that made this conference possible: The organizing committee, the mentors that volunteered their time to help young students, mid/early career scholars, and doctoral students, our leading and supporting reviewers, the staff at both host institutions, the session chairs and discussants, and all the presenters and participants. We especially thank our copy editor, Allison Hall, who worked countless hours over many months to prepare the proceedings. We also thank our student volunteers who put in personal time and effort to put together the poster sessions, help organize submissions, and assist the program and organizing committee. We extend special thanks to the following students: Amanda Barany, Kaitlyn Bright, Heather Tanner from Drexel University; Noora Noushad and Jooeun Shim from the University of Pennsylvania; Shulong Yan and Dhvani Toprani from Penn State University. Finally, many thanks to Aroutis Foster for his leadership and coordination of the conference logistics.

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Can We Rely on IRR?
Testing the Assumptions of Inter-Rater Reliability

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Abstract: Researchers use Inter-Rater Reliability (IRR) to measure whether two processes—people and/or machines—identify the same properties in data. There are many IRR measures, but regardless of the measure used, however, there is a common method for estimating IRR. To assess the validity of this common method, we conducted Monte Carlo simulation studies examining the most widely used measure of IRR: Cohen's kappa. Our results show that the method commonly used by researchers to assess IRR produces unacceptable Type I error rates.

Keywords: inter-rater reliability, coding, code validation, Cohen's kappa

Introduction

Inter-Rater Reliability (IRR) measures whether two processes identify the same properties in data. That is, it determines whether codes (or annotations or categorizations) are applied in the same way by two coders. In the context of Computer Supported Collaborative Learning (CSCL), it is often difficult, if not impossible, for a person to code an entire dataset. In these cases, researchers typically code a *test set*, or a subset of the data, and measure the IRR of the raters on the test set as a proxy for what their agreement would be if they were to code the entire dataset. But this raises a question: *Can we assume that the IRR measured for a test set generalizes to an entire dataset, or to a larger set of similar data?*

Prior work in CSCL on IRR is primarily concerned with the question of *which* IRR measure to use. Here we ask *how* IRR measures are used, and whether they are used appropriately. To investigate whether or not IRR measures are used appropriately, we conducted two Monte Carlo studies with the most popular IRR measure used in CSCL: Cohen's kappa.

Theory

In CSCL research, assessing the reliability of coding schemes using IRR is a *consensus estimate* (Stemler, 2004). There are many possible measures of IRR, for any IRR measure, the same basic method is used. For a given code: (1) A definition for the code is written. (2) A measure of IRR is chosen and a minimum threshold for acceptable agreement is set. (3) A test set of a specified length is randomly selected from the dataset. (4) Two independent raters code the test set based on the definition. (5) The agreement of their coding is calculated using the chosen IRR measure. (6a) If the IRR calculated is below the minimum threshold: the raters discuss their coding decisions; (I) they resolve their disagreements, often by changing the conceptual definition of the code; and (II) the raters repeat steps 3, 4, and 5. (6b) If the IRR calculated is above the minimum threshold, researchers conclude that the raters agree on the meaning of the concept, and the coding is considered to have construct validity. The two raters can then independently code the rest of the data.

We conducted a meta-analysis of four research journals in which CSCL research is commonly published: IJCSCL, JLS, JEDM, and JLA. We searched 225 IJCSCL articles from 2006 through 2016, and 491 JLS articles from 1997 through 2016 using the following search terms: inter rater, interrater, inter-rater, intra class, intraclass, intra-class, and reliability. We also read all 46 articles in JEDM from 2009 through 2015 and all 102 articles in JLA from 2014 through 2016. This meta-analysis found that more than 97% of CSCL research articles appear to follow this method. In what follows we refer to this progression as the *Common Method for IRR Measurement* (CIM).

When this method is described explicitly, it is clear that there is an implicit assumption when using the CIM: namely, that the IRR measured in the test set applies more broadly to data not contained in the test set.

We tested this assumption using a Monte Carlo method. *Monte Carlo* (MC) studies are one method commonly used to investigate the performance and reliability of statistical tests used in educational and psychological research (Harwell, 1992). In MC studies, researchers generate an *empirical sampling distribution*: a large number of simulated datasets and calculate a test statistic for each one. Type I and Type II error rates can thus be computed empirically and used to evaluate the performance of statistical tests under different assumptions about the properties of the population from which samples are drawn.

MC studies thus require construction of simulated datasets that reflect the properties of the distribution being modeled. In the case of IRR, MC studies require a specific type of simulated dataset, a *simulated codeset* (SCS) that models data coded by two raters. Such sets consist of binary ordered pairs—(1,1); (1,0); (0,1); and (0,0)—where the first number represents whether the first rater applied the code and the second number represents whether the second rater applied the code.

Parameters need to be specified to produce simulated data that more closely reflect the data produced by trained raters. This simulated data can then be used to investigate the performance and reliability of various IRR measures, allowing researchers to test the extent to which the CIM produces generalizable results.

In what follows, we describe a series of MC studies that assess the performance of the CIM using the most commonly employed IRR measure in CSCL: Cohen's kappa (hereafter, kappa), which we chose based on our meta analysis (described above) that showed kappa was used in 40% of articles that computed IRR.

We consider two conditions. First, we examine the case in which there is a large dataset (on the order of 10,000 items) and two raters code a small sample of the data as a test set. Second we considered cases, where the initial dataset is smaller (on the order of 1,000 items), and thus two raters are able to code a very large portion of the data (up to 50%). In each case, we ask whether the CIM produces acceptable Type I error rates, which we take here as <0.05.

Methods

Generation of simulated codesets

We identified four parameters necessary for generating SCSs: base rate, SCS length, kappa, and precision. (1) **Base Rate:** The frequency with which a code is applied by a single rater. (2) **SCS Length**: The total number of items in the SCS. Measures of inter-rater reliability are almost always invariant to permutation of the excerpts being coded; therefore, these first two parameters allow us to simulate the codes of the first rater as a series of 1s of length *base rate* × *simulated codeset length* followed by a series of 0s of length *(1 – base rate)* × *simulated codeset length*. To compute the simulated codes for the second rater, we need two additional parameters. (3) **Kappa**: We used kappa (Cohen, 1960) to specify the overall level of agreement between the two raters. (4) **Precision**: The base rate and SCS length produce a unique set of codes for the first rater. However, one can produce multiple sets of codes for the second rater for any given kappa because kappa does not distinguish between positive and negative agreements. To address this, we used *precision*, which measures the likelihood the first rater thought the code was present if the second rater thought the code was present.

These four parameters identify a unique set (ignoring permutations) of ordered pairs $\{(f_i,s_i)\}$ that represent the codes for the first rater, f_i, and the codes for the second rater, s_i, for each item *i* in the SCS. Our meta-analysis of CSCL and related research provided limited guidance on appropriate ranges for these parameters for the purpose of modeling what two raters in the field would produce when coding qualitative data. Therefore, for our MC simulations, we empirically derived conservative estimates of what two trained human raters would reasonably produce for base rate, kappa and precision, based on the performance of raters observed in our own lab. For example, we typically find base rates for discourse codes in the range of 0.01 to 0.30. While base rates for codes are not typically reported in studies, we believe that these rates are not atypical in CSCL research. Simulated data generation parameter ranges were: base rate (0.01, 0.05, 0.10, 0.20, 0.30, 0.50; simulated codeset length (10,000 [MC Study 1] & 1,000 [MC Study 2]); kappa (0.30 – 1.00): precision (0.60 – 1.00). Simulated codeset length was held constant in both MC study 1 and MC Study 2.

To construct a SCS, we thus (a) chose a base rate and SCS length to calculate the number of 1s and 0s produced by the first rater, (b) randomly selected a value from our range of kappas, and (c) randomly selected a precision from the estimated range until it formed a valid (mathematically possible) combination with the kappa previously selected.

MC simulation construction

Using the SCS generation method described, we developed a *simulated IRR measurement* (SIM) method to model the CIM based on three additional parameters: (1) **Test Set Length:** We specified a *test set length* as in the CIM (CIM Step 3). A review of the literature indicated that researchers use a variety of test set lengths. For example, De Laat and Lally's (2004) used a sample of 10% of their dataset of 160 messages. In contrast, McKenzie and Murphy (2000) chose to sample one-third of the 151 messages containing 271 message units. None of the researchers justified the choice of a particular test set length. In MC study 1 (SCS length = 10,000), we used test set lengths of 20, 40, 80, 160, 200, 400, and 800. In MC study 2 (SCS length = 1,000), we used test sets lengths of 2%, 4%, 8%, 16%, 20%, 40%, and 50% of the SCS length. (2) **Replicates**. We empirically derived the number of *replicates*, or the number of times we needed to simulate the CIM to be confident in our calculation of error rates. To do so, we incrementally increased the number of replicates until the standard deviation of the Type I error rates decreased to less than or equal to 0.01. This result was achieved for all of the simulation in our MC studies with 12,000 replicates. (3) **Thresholds**: We used a threshold of 0.65 for kappa, which is consistent with the most commonly used threshold (Cohen, 1960; Viera and Garrett, 2005).

To complete the MC studies, we applied the SIM method as follows: (1) We chose a base rate and test set length and created 12,000 sets using our SCS generation method—this simulates the coding of the data (CIM step 4). (2) We computed kappa for each SCS, which represents the true IRR rates for two coders. (3) We randomly selected a *test set* from each SCS at the given test set length, which represented the number of excerpts the raters actually coded—that is we took a sample of the dataset (CIM step 3). (4) We computed kappa on the test set (CIM Step 5). (5) We computed the Type I error rate (*false positives*, or all test sets with IRR above the corresponding threshold) for kappa (CIM Step 2 & 6b)—where a Type I error was defined as a case where the agreement measured by the IRR test statistic in the test set was above the threshold of 0.65 and the actual agreement in the SCS was below the threshold. We repeated the SIM process for all combinations of base rates and test set lengths.

Findings

RQ1: Does the CIM using kappa produce acceptable (< 0.05) Type I error rates when two raters code a small subset of the data? In MC Study 1, we conducted 42 simulations, each containing 12,000 SCS with lengths of 10,000, using base rates from 0.01 to 0.50 and test set lengths from 20 to 800 (see Table 1). Of these 42 simulations, only 4 had Type I error rates less than 0.05. These 4 had test set lengths of 400 or higher, and base rates of 0.20 or higher. The remaining 38 studies all had Type I error rates greater than 0.05. Of those 38 studies, 15 studies had Type I error rates greater than 0.20. This suggests that the CIM for kappa produces valid results only for large test sets with base rates that may be larger than are typically seen in CSCL research.

Table 1: SIM method using kappa Type I error rates - MC Study 1 (simulated codeset length = 10,000)

		Test Set Length						
		20	40	80	160	200	400	800
Base Rate	0.01	0.304	0.355	0.367	0.383	0.364	0.297	0.199
	0.05	0.255	0.347	0.280	0.210	0.182	0.123	0.073
	0.10	0.228	0.256	0.179	0.132	0.118	0.078	0.061
	0.20	0.216	0.196	0.132	0.097	0.083	0.053	***0.039**
	0.30	0.229	0.168	0.110	0.077	0.0728	0.050	***0.035**
	0.50	0.204	0.136	0.095	0.073	0.059	***0.044**	***0.034**

RQ2: Does the CIM using kappa produce acceptable (< 0.05) Type I error rates when two raters code a large subset of the data? In MC Study 2, we conducted 42 simulation studies, each containing 12,000 SCS with lengths of 1,000, using base rates from 0.01 to 0.50 and test set lengths from 2% (20) to 50% (500) of the SCS length. Of these 42 simulations, all but 6 had Type I error rates greater than 0.05. All of these 6 used test set lengths of 40% (400) or higher, and base rates of 0.20 or higher. Many of the remaining simulation studies had Type I error rates greater than 0.20. This suggests that the CIM using kappa produced valid results only for large test sets with base rates that may be larger than are typically seen in CSCL research.

Discussion

The results of our MC studies show that the CIM has high Type I error rates: greater than 0.05 except in the few cases where codes have very high base rates *and* test sets that are larger than those typically found in CSCL research. In many cases, Type I error rates are near or above 0.30, meaning a third of the test sets generated a kappa that exceeded the threshold, but the kappa of the entire dataset did not. In over one third of the cases we examined, Type I error rates were greater than 0.20.

Our results highlight a critical problem for CSCL researchers. Because the CIM does not control for Type I error rates, researchers must code a prohibitively large amount of data to obtain reliable IRR with the CIM. More generally, though, our results point to significant issues (significant in both the statistical and practical sense) with the reliability of the CIM. The problem, of course, is that the CIM assumes that a statistic (in this case, an IRR measure) computed on a sample (in this case, the test set) provides a good measure of the value of the statistic in some population (in this case, the rest of the data being coded).

A critical job of statistical methods is to establish whether such inferences are warranted given the properties of a sample. Thus, we believe the results here suggest that statistical methods need to be used to establish the reliability of coding regardless of the IRR measure used.

Although it is beyond the scope of this preliminary paper, we have developed such a method by treating code validation as a sampling problem and using a Monte Carlo hypothesis testing method to calculate a pseudo p-value, *Shaffer's rho*, that estimates the Type I error rate for an IRR measure given a test set coded by two raters. This method has been outlined in a working paper (Shaffer et. al., 2015) and is available as an R package. We will describe the method in detail in a subsequent publication, but briefly, *Shaffer's rho*: 1) Has acceptable type I error rates (< 0.05); 2) Can be used with any IRR measure; 3) Statistically tests whether an IRR measure generalizes to the entire dataset and population of interest; and 4) Allows for validation of low base rates codes, which has historically been difficult for researchers.

Whether researchers ultimately choose to adopt *rho* or another statistical test, the results here suggest that the current, widely-accepted approach to IRR should be used with caution in most circumstances that CSCL researchers are likely to encounter in their work. This issue will become only more critical as CSCL research continues to use datasets with tens or hundreds of thousands of items, making it impossible for human raters to code more than a tiny fraction of the data by hand.

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To What Extent Students' Epistemic Beliefs Influence Their Engagement in Argumentative Discourse and Attitudinal Change

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Abstract: This study investigates how students with various epistemic beliefs engage in argumentative discourse and shift their attitude within a digital dialogue game. Participants were randomly assigned to groups of four or five and asked to argue and explore various perspectives of four controversial issues of environmental education in four consecutive weeks that each lasted 90 minutes. Epistemic beliefs of students were seen to be an important factor for the way they engage in argumentative discourse and also their attitudinal change.

Keywords: attitudinal change, epistemic beliefs, learning, argumentation

Introduction

Argumentation is a vehicle for collaborative learning process not only for traditional forms of classrooms but also for blended and online learning settings such as open and distance learning programmes in higher education (see Noroozi et al., 2012). Argumentation is considered to be significant to education due to the importance of discourse in the acquisition of scientific knowledge (see , Noroozi et al., 2013b, 2017; Osborne, 2010).

An important factor for the extent to which students engage in, or avoid, critical reasoning and arguments is their epistemic beliefs (see Nussbaum et al. 2008). Epistemic beliefs colour student interactions within argumentative discourse, leading some students to hold back from interactions. Epistemic beliefs can be defined as one's own opinion on the nature, structure, and certainty of knowledge and justification for knowing with regard to knowledge acquisition (see Hofer, 2000; King & Kitchener, 1994). From this perspective, students' epistemic beliefs can be labelled as: (a) absolutism, (b) multiplism, and (c) evaluativism. Absolutists view knowledge as objective, simple, certain, and fixed that cannot be changed meaning that there is only one right or wrong answer and only authority figures have those answers. Multiplists perceive knowledge as subjective and contextual where viewpoints are seen as mere opinions. In this case, students are exposed to various perspectives of the issue at hand with the aim of concluding that one point of view is as good as another. In the most developed and sophisticated scenario, evaluativists perceive knowledge as verified true belief meaning that there are multiple possibilities in which knowledge claims must always be evaluated for their quality of arguments in different contexts (see Muis, 2007). Scientific empirical evidence has shown that students engage in argumentation differently with respect to their epistemic beliefs. For example, multiplists are less critical regarding inconsistencies and misconceptions and less interactive with their partners than other belief groups (Nussbaum et al. 2008). It is also shown that evaluativists are more critical and active in eliciting information from their partners (Nussbaum et al. 2008), compared with absolutists who are less inclined to explore alternative solutions (Oh & Jonassen, 2006).

Epistemic beliefs can therefore be seen as a factor that influences the way students engage in argumentative discourse and critical discussion and reasoning (see Noroozi, 2016). Prior research has not investigated the effects of epistemic beliefs on student argumentative discourse when student willingness to argue is enhanced by such activity design. The picture is also unclear in terms of whether confrontation of students with various viewpoints during argumentative discourse lead to modification of their attitudes towards the topic(s) of discussion. With regard to willingness to argue, since argumentation and debating involve social learning processes (O'Keefe, 1982) and guide student attention towards exploring various sides of issue at stake (Noroozi et al., 2011, 2013a, 2013c; Nussbuam et al., 2008), we hypothesise that students' attitudes towards controversial issues would be modified after the discourse. The goal of this study is to explore how students with various epistemic beliefs engage in argumentative discourse by exposing them to controversial topics and conflicting views within a dialogue game which is fun to play, but encourages challenges. Furthermore, we explore the role of students' epistemic beliefs on their attitudinal change.

Methods

The study took place at Wageningen University in the Netherlands. The participants were 29 MSc/BSc students who enrolled for the 168-h course "Applied Environmental Education and Communication". The mean age of the participants was 23.34 (*SD* = 2.71). About 59% of participant were female and 41% of participants were male. Participants were divided into groups of four or five students on a random basis. The topic for discussion was different for each week. The dialogue game took place in four consecutive weeks providing that each week one of the main themes of the course is touched through the dialogue game. The students' task was to read materials, discuss, and argue the topic with other members in the group while taking into account the various perspectives on the need – or lack thereof – of the topic of the discussion for each week.

The learning partners in each group were distributed over different locations of a classroom. The digital learning environment was called "InterLoc" which is a synchronous text-based discussion board. InterLoc stimulates dialogue between group members in an active and structured environment by guiding students think and reason together. A variety of sentence openers are embedded in the InterLoc for provoking and promoting students' reasoning and the argumentative dialogue processes and practices of the players. For example, 'I agree because...' encourages a player to provide fully reasoned agreement. Other types of sentence openers deal with statements, evidence, support or criticism, and conclusions. Furthermore, a key feature of the game is the list of suggested openers for players' reactions to others, dynamically based on what has gone before. The list of replies is derived from a conception of how a well-reasoned discussion should proceed, e.g. from statements to fuller explanations, and from evidence to deriving justified conclusions. The epithet of a 'dialogue game' accurately describes the interactions within the discussion, as in a game there are rules about what dialogue moves can be made at different times, and so it is with InterLoc (see McAlister et al., 2004; Ravenscroft & McAlister, 2006).

One week prior to the start of the dialogue game, students were asked to complete several questionnaires through the online survey (30 minutes) on demographic variables, preliminary environmental attitude and their epistemic beliefs. The dialogue game was conducted in four consecutive weeks that each lasted 90 minutes. The first week of the study lasted almost 140 minutes. This was due to the introductory verbal explanations on the purpose of the game by the researcher (10 minutes) and students orientation and acquaintance to the InterLoc with its functionalities followed by a short 'hands-on' training exercise (40 minutes). Then, the dialogue game began and lasted 90 minutes. The second and the third sessions lasted only 90 minutes because there was no need for the introduction, orientation, and acquaintance to the InterLoc anymore. The last, forth, session lasted 140 minutes again. The dialogue game (90 minutes) was followed by a 10 minutes break. Students were then asked to state their environmental attitude positions on controversial issues that were touched during the four-week dialogue game (10 minutes). Finally, there was a plenary verbal session in which students expressed and shared their opinions on their experiences using the game with fellow classmates and also the teacher and the researcher (30 minutes).

Measurements

A pre-test post-test questionnaire was used to measure students' attitudinal change on the environmental issues that were touched during the four-week dialogue game sessions. This questionnaire consisted of two questions for each session (in total eight questions) on a five-point Likert scale ranging from "strongly disagree", "disagree", "neutral", "agree" through to "strongly agree". Specifically, both in the pre-test and post-test, each student was asked to indicate the extent to which s/he agreed with the environmental attitude statements (see Table 1). The data from post-test was compared with the pre-test data in order to detect any shift of the student attitude towards environmental issues. For each question, there could be a maximum of four-point shift (for example from strongly disagree to strongly agree and vice versa) on the environmental attitude on the basis of the Likert scale. Taking into account the five-point Likert scale together with the total eight questions on the environmental attitude, as a maximum, 32 points could be scored by each student.

We measured students' epistemic beliefs using a 15-item instrument developed by Kuhn et al. (2000) according to the judgement domains. Based on the data from this questionnaire, each student was classified into three epistemic orientations: Absolutists, Multiplists, and Evaluativists (see Kuhn et al., 2000; Nussbaum et al., 2008). An Absolutist believes that only one answer could be right. A Multiplist believes that all opinions can be equally valid. An Evaluativist believes that criteria exist whereby opinions/judgements can be evaluated and one can be shown to be better than another.

A content analysis coding scheme was adapted to measure quality of argumentative discourse activities (see Weinberger & Fischer, 2006). Every message posted during the discussion was coded as one of the following: externalization, elicitation, agreement, integration, disagreement, off task (Noroozi et el., 2016).

Findings and discussions

There were a total of 2927 discussion messages generated during the discourse, with an average of 103.76 per student (*SD* = 35.53). 909 messages were categorized as externalization, 455 as elicitation, 900 as agreement, 341 as integration, 294 as disagreement, and 28 messages as off task. Each student in average produced 31.34 (*SD* = 9.70) externalization messages, 15.69 (*SD* = 12.37) elicitation, 31.03 (*SD* = 14.05) agreement, 11.76 (*SD* = 6.07) integration, 10.14 (*SD* = 5.62) disagreement, and only .97 (*SD* = 1.50) off task messages.

The results show that 18 (62%) of the participants were classified as Multiplist, 11 (38%) as Evaluativist and none as Absolutists. MANOVA repeated measurement test showed that Evaluativists engage in argumentative discourse in a different style than Multiplists do, Wilks' $\lambda = .64$, $F(1, 25) = 2.02$, $p < .1$, $\eta 2 = .35$. Specifically, Evaluativists produced higher number of externalization messages ($M = 35.82$, $SD = 8.57$) compared with Multiplists ($M = 28.61$, $SD = 9.54$); $F(1, 25) = 4.20$, $p < .05$, $\eta 2 = .14$. Evaluativists also produced higher number of integration messages ($M = 14.18$, $SD = 6.82$) compared with Multiplists ($M = 10.28$, $SD = 5.21$); $F(1, 25) = 3.03$, $p < .1$, $\eta 2 = .10$. There were no differences between Evaluativists and Multiplists in terms of total number of agreement messages, elicitation, disagreement, number of messages, and producing off-task messages. The results show an effect of epistemic beliefs on the style and frequency of particular types of contribution by students. Multiplists were expected to interact less and be less critical than Evaluativists. Therefore, it was assumed that Evaluativists would produce higher number of messages and that they would mostly engage in high level of discourse transactions such as disagreement and integration. These expectations were confirmed in this study. Evaluativists produced higher number of total messages as well as disagreement and integration messages compared with Multiplists. Previous studies had found differences in the style and strength of interactions within the discussion emerging from the differences in epistemic beliefs (Kuhn et al, 2000; Nussbaum et al. 2008). Unlike our expectation and also unlike previous research (Kuhn et al, 2000; Nussbaum et al. 2008), Evaluativists produced higher number of externalization messages compared with Multiplists. One would expect that Multiplists produce more externalization messages than Evaluativists since externalizations are viewed as the least interactive category. This could be explained by the specific context of the study. The controversial issues of environmental education caused quite passionate and personal views on both side of the argument, increasing students willingness to outline and externalize their information for others regardless of their epistemic orientation.

ANOVA test showed that students' epistemic beliefs play a big role for the extent to which students change their attitude. The difference between the total number of shifts of opinions on environmental issues was statistically significant between Evaluativists and Multiplists, $F(1, 28) = 4.34, p < .05$. Evaluativists ($M = 7.36$, $SD = 2.94$) shifted their opinions on the environmental issues much more than Multiplists did ($M = 5.16$, $SD = 2.64$). The argumentative discourse in this study caused most students to change their positions and shift their opinions, an outward sign that the activity initiated thinking, and rethinking, among the students. This has to do with the nature of argumentation that involves social process (O'Keefe, 1982) that can facilitate students' consideration of alternative viewpoints (Nussbuam et al., 2008). The results show a strong effect of epistemic beliefs on the attitudinal change of students. The expectation was that Multiplists would interact less and be less critical of their peers than Evaluativists. It was then expected that Multiplists would be less susceptible to attitude shifts than Evaluativists. Due to more openness to persuasion and argumentation of Evaluativists compared with Multiplists, they took more advantage of the knowledge distributed in the group and integrated them with their own prior opinions to revise, modify, and adjust their initial contributions. The change between being neutral to supporting a proposal about environmental issues is a relatively large change for a student studying the topic, so none of the attitude shifts recorded were trivial or unconsidered to the students involved.

Conclusions and implications

This study used a learning activity design to engage higher education students in an intensified debate for exchanging and directing diverse conflicting opinions towards deeper reasoning and engagement using a digital dialogue game. Students' epistemic orientation was seen to be a crucial factor on their style of argumentation, engagement in the discourse, and their openness to persuasion and attitudinal change.

This study reminds us of the many variables at work within a learning design affecting willingness to argue and engagement in argumentative discourse. They include the ecological validity of the setting, knowledge and pertinence of the issue at hand, students' epistemic beliefs, and, by no means least, the style of engagement. Outcomes are not determined by one variable alone, so learning designers will need to keep in mind the full range of factors that will facilitate thoughtful and deeper argumentation.

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Children's Emergent Leadership and Relational Thinking in Collaborative Learning

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Abstract: Children's emergent leadership is an important but often ignored component of peer-led collaborative learning. Existing research suggests that emergent leadership develops when children are given the autonomy and space to regulate group dynamics on their own, which often assists the group to achieve better outcomes within the collaborative activities. However, it is less known whether the emergence of child leadership also promotes deeper and more connected reasoning *during* collaborative learning. This current study, by coding emergent leadership and relational thinking from two sets of small group discussions (25 in total), revealed that over time, children exhibited more leadership and relational thinking in the second collaborative discussion than their first one. In addition, *intellectual leadership* moves, rather than *organizational leadership* moves, were positively related to generation of relational thinking. We discuss the implications of the study to help children, particularly minority children from underserved communities, to developing leadership and relational thinking through participating in intellectually stimulating collaborative discussions.

Keywords: child leadership, relational thinking, collaborative learning, development, Collaborative Reasoning

Introduction

Understanding how to support productive social interactions in collaborative learning has become more important, as research shows that without productive peer interactions, even groups with good ideas could fail (Barron, 2003). Besides individual self-regulation, Järvelä and Hadwin (2013) pointed out co-regulation and social regulation among group members plays a key role for collaborative learning to succeed. Socially-shared regulation refers to the regulatory strategies that a group utilizes, to coordinate their collective thinking, actions, and emotions, that help the group achieve its goals. Social regulation can be examined from different angles, and emergent leadership is one of them (Miller, Sun, Wu, & Anderson, 2013).

Emergent child leadership is defined as a reciprocal social process during which some children coordinate, enhance, or guide the behavior of other children (Miller, Sun, Wu, & Anderson, 2013). It is an important but often ignored component of successful collaborative learning groups. Though limited, research that examined children's emergent leadership in both face-to-face and computer supported learning environments has confirmed the benefits of emergent leadership on the productiveness of collaboration (e.g. Yamaguchi, 2004; Cassell, Huffaker, Tversky, & Ferriman, 2006). A microgenetic study of children's emergent leadership, led by Li and her colleagues (2007), found five commonly occurring leadership moves in children's discussion groups: argument development, topic control, turn management, planning and organizing, and acknowledgement. Based on Li et al.'s study, Mercier (2014) coded children's emergent leadership into intellectual and organizational categories, and found that individual children tended to primarily use one type of leadership move instead of both.

Previous research on the impact of children's emergent leadership has primarily focused on how leadership helps the group to achieve better outcomes. For example, research shows that more effective leadership moves helps groups produce better solutions to problems (Mercier et al., 2014; Sun, Anderson, Perry, & Lin, in press), and also promotes group members' positive feelings towards collaboration (Sun et al., in press). However, there has been limited research examining the impact of leadership on the process of collaboration. We know little about whether emergent leadership produces a higher quality of reasoning during collaboration, such as relational thinking.

Relational thinking, as stated by Holyoak (2012), refers to the individual ability to form coherent schemas through conceptualizing, generating, and manipulating relations between different concepts. Such ability to recognize relations through surface and deep levels often sets the foundation for deep learning to occur, such as the transference of knowledge and skills, and conceptual change. Previous research that examines relational thinking in the classroom shows that teacher scaffolding influences children's use of relational thinking. Lin et al. (2015a) found that when teachers use prompts based on relational thinking, versus lower level prompts such as requesting facts or definitions, students in turn generate more relational thinking. Research has also confirmed that peer relationships, such as individual social status and group level social support, play an important role in students' increased use of relational thinking (Lin et al, 2015b). Besides this emerging inquiry on relational thinking in collaborative learning, it is uncertain whether emergent leadership, a reciprocal social process and dynamic form of peer interactions and group regulation, could also influence children's development in relational thinking. This study therefore aims to fill in the research gap, by exploring the relationship between emergent leadership and relational thinking in Collaborative Reasoning discussions.

Collaborative Reasoning (CR) is a free-flowing, peer-managed approach to discussion intended to stimulate critical reading and thinking and to be personally engaging (Anderson, Chinn, Waggoner, & Nguyen, 1998). Children read stories about controversial issues that cover ethical or practical dilemmas or child-friendly public policy or scientific issues. They take positions on a Big Question raised by a story and present reasons and evidence for and against these positions, with the goal of collaboratively coming up with the best answer to the Big Question. In a CR discussion, teachers are encouraged to step back and reduce their talk, making more room for students to decide when to speak and what to say. Students independently manage the flow of the discussions for the majority of the time, and teachers occasionally provide scaffolding when it is necessary.

Methods

Participants

128 fifth-grade children from six classrooms with a predominant population of African American students from Midwest America participated in this study. Depending on the school, between 79% and 99% of the participating students were registered for free or reduced-priced lunch.

Procedure

During the intervention, the participant classrooms learned a six-week curriculum about wolf reintroduction and management in collaborative group work. The curriculum includes three packets: ecosystem, economy, and public policy. Each packet comprised of readings specific to the topic, and an activity booklet that contained various activities and problems that reinforced and expanded the concepts presented in the readings. Students role played as officials in the Wolf Management Agency while learning the curriculum, and had to make an informed decision on a Big Question about whether or not they should give permission to hire professional hunters to kill a pack of wolves that posted a threat to a fictional town.

The study employed a jigsaw design. Teachers helped split the class into three or four heterogeneous groups, where each group held an initial Collaborative Reasoning discussion based on their naïve opinions about the Big Question (BQ 1). About one third of the groups were videotaped. Groups were then assigned one of the three topics (ecosystem, economy, or public policy) to become experts on by learning the information booklet and completing the activities together. After finishing their expert topic, children were shuffled into new groups to hold a second Collaborative Reasoning discussion about the same Big Question, but with their informed perspectives (BQ 2). All of the second discussions were videotaped. Detailed descriptions of the study can be found in Ma et al. (2016).

Data sources and analyses

The current dataset includes full transcripts of the six groups' first Collaborative Reasoning discussions (BQ 1), and systematically sampled 6-minute episodes from all of the 19 new groups' second Collaborative Reasoning discussion (BQ 2). In sum there are 25 discussions.

Coding for children's relational thinking

Children's relational thinking was examined turn by turn throughout the 25 discussion transcripts using the coding scheme created in Lin et al. (2015), which included two major categories of 1) logical or causal, and 2) analogical or hypothetical relational thinking. Logical or causal keywords and key phrases included *because, if, so* and *so that*, where statements were based upon conclusions. Analogical or hypothetical relational markers included keywords and key phrases such as *what if*, *if you were*, *is like*, *just like*, *the same as* and *so as*, where inferences were made by relating material to hypothetical scenarios. After speaking turns that included these keywords and phrases were identified, statements were checked in the context to determine if they truly served as one of the two relational thinking functions. About 20% of the relational coding was checked by a different researcher, and the intercoder agreement percentage was 98% (Cohen's Kappa = .90).

Coding for emergent leadership

Children's leadership moves were initially identified using the coding scheme created by Li and colleagues (2007), which primarily included five categories of *argument development*, *topic control*, *turn management*, *planning and organizing, and acknowledgement*. Due to the infrequency of *acknowledgement* (n=1), we dropped it from the coding results, and kept the rest of the four leadership moves. In the second step of coding, we applied the categorization developed by Mercier, Higgins, & de Costa (2014), and combined *argument development* and *topic control* into *intellectual leadership,* and *topic control* and *turn management* into *organizational leadership*. About 10% of the leadership coding was checked by a second coder, and the intercoder percentage of agreement was 88% (cohen's kappa = .76).

Findings

Overall, there were 2,592 turns from the 25 transcripts, of which 473 (18.25%) speaking turns contained relational thinking, and 207 (7.99%) showed the use of at least one type of leadership move. To adjust for the variance in the length of the discussion transcripts, numbers of leadership moves and relational thinking coded within each transcript were standardized by dividing the total speaking turns of that transcript.

As shown in Figure 1a and Figure 1b, children used more leadership moves, and generated more relational thinking, in the second Big Question discussion compared to the first one. In both discussions, *intellectual leadership* moves were positively related to relational thinking (r_{BQ1} = .16, r_{BQ2} = .43). This trend can be seen in the following example where student A made a leadership bid of argument development for student B, who compared dogs and wild wolves to support his argument that wolves should be killed.

Student A: Why don't you give us-or a good reason why they should [kill the wolves.]

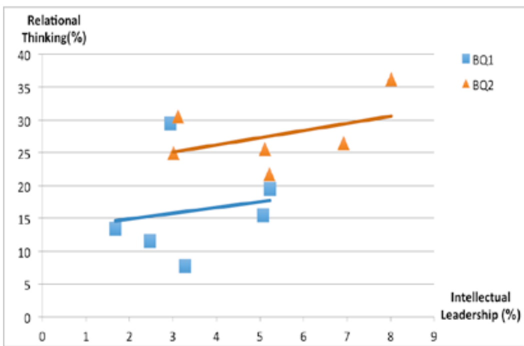
Student B: Because they're dangerous wild animals. They're not-they're not (dogs) like-to the point where you could like take care of them. Mmmmm. You could take care of them, but not like one of your own like a (a parrot) or something."

Organizational leadership moves, however, negatively correlated with relational thinking (r_{BQ1} = -.12, r_{BQ2} = -.53). This is perhaps due to the nature of organizational leadership, where a majority of attempts were to take control of or change the direction of the conversation. Organizational moves were also found to lead to simple yes and no answers, rather than lengthy explanations, thus may not promote or even inhibit relational thinking. This can be seen in the following example, where student C tried to summarize the group's decisions by asking group members to restate their positions. Though such leading gesure helped everyone to see each other's standing, the flow of the discussions was also interrupted.

Student C: Yeah but she didn't say all that. Alright who thinks yes? (Several students raise their hands.) And no? (Two students raise their hands.)

Student D: Sort of...

Student E: How about you [pointing to student F]



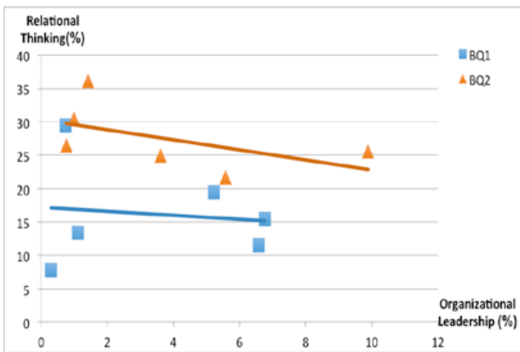


Figure 1a. Correlation between *Intellectual Leadership* and Relational Thinking in BQ 1 and BQ 2.
Figure 1b. Correlation between *Organizational Leadership* and Relational Thinking in BQ 1 and BQ 2.

The initial results can be interpreted that over time, children developed emergent leadership skills and an ability in using relational thinking. In classes where *intellectual leadership* moves emerged, children were also more likely to use relational thinking that contains hypothetical, analogical, and causal reasoning. However, in classes where there were many *organizational leadership* moves, children's likelihood of using relational thinking decreased. The initial findings are intriguing, and in order to understand why these two types of leadership moves had completely opposite relationships with relational thinking, we are currently under closer examination of features of these two different types of leadership moves. In order to take advantage of the temporal information reserved from the transcripts of the collaborative learning process, we will conduct sequential analysis in the next step to further explore the immediate and delayed impact of *intellectual* and *organizational leadership* moves on children's relational thinking. We expect to answer questions such as: If a child requests his or her peers to provide clarification of their thinking, will this immediately trigger relational thinking from the rest of the group? Does conversation and relational thinking stall following *organizational leadership* moves?

Conclusions and implications

Findings from this current research speaks directly to the intertwining nature of children's social and cognitive development during collaborative learning. Children's emergent leadership, including organizational and intellectual leadership, was closely related to their relational thinking. Additionally, the participants in this current study were primarily minority children from under-served communities with a high poverty rate. Children from such communities often lack the opportunities to work on challenging activities collaboratively. The study shows that Collaborative Reasoning and group work can be an alternative instructional method to provide intellectually stimulating environments where students naturally develop essential skills such as deep learning and leadership. Findings from this study, though representing a face-to-face collaborative learning activity, may also have implications for computer supported collaborative discussions. The initial findings indicate that to help students further develop relational thinking, tools that help students to plan and organize group dynamics at appropriate timing could be particularly beneficial.

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Exploring Student Engagement in an Augmented Reality Game

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Abstract: It has been argued that approaches to education should embed learning in activities that reflect the social and physical environments in which the knowledge is relevant. Over the past ten years it has become possible to situate learning in a variety of novel contexts using augmented reality (AR) games. This study investigates the behaviors of middle school students during their participation in an AR game called *Play the Past*. The findings of this study show that engagement differed during discrete activities in the game environment and that there was a relationship between the roles that students were assigned and their engagement.

Situated cognition and augmented reality

In order to study how individuals learn it is necessary to consider how they interact with an activity, environment, and social processes to affect learning outcomes. Researchers studying situated cognition claim that these factors are integral to the learning process (Brown, Collins, & Duguid, 1989), and have the capability to enhance or depress a person's ability to learn (Hendricks, 2001). Based on these studies, it is clear that education should embed learning in activities that reflect the real-world social and physical environments in which the knowledge is relevant. Today more than ever, it is possible to situate learning in meaningful ways by using new technologies, such as, augmented reality (AR) games. AR is defined as a view of the physical environment that has been enhanced by virtually overlaying information onto it that can apply to all senses (smell, touch, hearing, visual, etc). Thanks to these affordances, AR has the potential to significantly enhance learning environments, especially when combined with the engaging qualities of digital games.

Design principles for AR games

AR games make it possible to situate learning in a relevant and engaging environment, leverage social processes, and create engaging activities. For example, Dunleavy, Dede, and Mitchell (2009) created an AR game that allowed students to investigate the crash landing of an alien spacecraft, while learning a variety of math and science concepts. Although there were some caveats and limitations to the implementation of this game, students who went through this experience were highly engaged and wanted to learn more to solve the mystery. Klopfer, Perry, Squire, and Jan's (2005) study found that the types of roles that students took on in the AR environment affected their level of engagement. Specifically, they found that higher interdependence and interaction between distinct roles increased collaboration and engagement.

Recently, three additional design principles for learning in AR games were established by Dunleavy (2014). He established these principles in order to enhance the unique capabilities of AR and minimize the weaknesses of the technology. The first design principle offered by Dunleavy (2014), is that AR learning experiences should "enable and then challenge", which means that users in these environments should be acclimated to the experience and then challenged with more complex tasks. For example, in the AR game, Dino Dig (http://www. playfreshair.com/), players are given tasks of increasing complexity starting with navigating to a location, then gathering information, and finally completing a challenge or interacting with another player. Second, Dunleavy (2014) advocates for AR learning experiences to be, "driven by gamified story". For instance, *Alien Contact!* provides a compelling narrative, where "aliens have crash landed near the students' middle school", and the students must investigate why the aliens have come to their planet (O'Shea, Mitchell, Johnston, & Dede, 2009). Third, Dunleavy (2014) recommends that learning experiences in AR should allow the users to, "see the unseen", which is an inherent capability of AR, because information can be overlaid on the physical world. This design principle is exemplified by an exhibit at the *San Diego Zoo*, where students learn about the anatomical composition of animals at the zoo, through the virtual presentation of 3D models of the animals represented on the sign.

Current study

Play the Past guides students to explore history in an engaging and fun way while on a field trip to the Minnesota History Center. The game is divided up into three hubs (Sod House, Fur Trade, and Iron Mine), that are located within specific areas of the *Then Now Wow* exhibit where students must master different roles (Hunter, Clerk, Iron Miner, Farmer), and interact with other students to master tasks and complete levels.

The majority of the design principles mentioned above are stable across the hubs in *Play the Past*, including the need to scaffold the learning experience, the use of narrators as guides, and the AR game providing the user with the ability to "see the unseen" (Dunleavy, 2014). However, students take on very different types of roles in each of the hubs within *Play the Past* that promote different levels of interdependence and collaboration. The Sod House and Iron Mine are primarily single-player narrative games, where students interact with a narrator to complete different tasks that were relevant to someone living in that historic scenario. The Fur Trade is the only multi-player game that requires interdependence and collaboration between students, because each student is assigned to one of two distinct roles (Clerk or Hunter) that must trade goods with each other to complete the hub.

Hypothesis 1. Based on the design principle proposed by Klopfer and colleagues (2005), we hypothesize that students will be more engaged with the Fur Trade, than the Iron Mine or the Sod House.

Each of the distinct roles (Hunter or Clerk) that students are assigned to within the Fur Trade also vary in difficulty. This will allow us to compare and contrast engagement levels across two different difficulty scales, and investigate this design principle in detail proposed by multiple studies in the past (Klopfer & Squire, 2008; Dunleavy, 2014).

Hypothesis 2. Thus, we hypothesize that students who are assigned to be a hunter will have a higher level of engagement with the game than students who are assigned to be clerks, because of the difference in the level of difficulty between the two roles.

Methods
This study investigates the behaviors of middle school students during their participation in an AR game called *Play the Past*. The study primarily employs an observational design to draw inferences about how subjects are affected by exposure to an environment or intervention (Carlson & Morrison, 2009).

The sample for this study consists of 7,129 4th to 6th grade students from 95 urban elementary schools in the upper Midwest. These students participated in *Play the Past* between September 1, 2014 and June 3, 2015.

AR environment
Play the Past is embedded in the Minnesota History Center's *Then Now* Wow exhibit, which is focused on several different periods of Minnesota history. It is divided up into hubs (Sod House, Fur Trade, and Iron Mine), that are located within specific areas of the exhibit, where students must master different roles (Hunter, Clerk, Iron Miner, Farmer) and tasks to complete levels. Each hub includes QR (Quick Response) codes on artifact surfaces, which students scan with their iPods (Figure 1) to progress through levels in each hub. The *Play the Past* application collected data from each student through their iPod. All data was sent to a secure Structured Query Language (SQL) database.

Figure 1. Image of a student scanning a QR code in the Fur Trade.

Procedure
All of the students who participated in *Play the Past* were on a field trip at the Minnesota History Center with their class. Each class included between ten and forty students. Students spent 38.3 (SD = 7.17) minutes in the game. During their participation, students had access to peers, chaperones, teachers, and staff for help navigating the simulated environment. Upon arrival at the museum, students were introduced to the iPod and how to use it to participate in the game. Afterwards, students were allowed to explore and complete the different hubs and levels as they pleased.

In the Fur Trade hub, students are challenged to help Monsomanain an Ojibwe hunter to gather beaver pelts that they can trade for goods, or John Sayer a company clerk that must make a profit off of trading their goods for beaver pelts. Once students are assigned roles and have gathered their supplies they negotiate trades with each other. Once a pair has negotiated and agreed on a trade both parties must confirm the trade of goods through the game. The Fur Trade hub is divided into two levels that are described in detail below:

Level 1: Students are assigned different roles where they help a hunter or a store clerk. In order to complete the first level, students helping the hunter must "trap" eight beaver pelts by scanning QR codes on beaver floor tiles to prepare for trading. Students helping the clerk must use ten beaver pelts provided on credit from the Fur Company in Montreal to stock their store. These are independent tasks that do not require collaboration between students.

Level 2: Students use the goods they obtained in Level 1 to trade with each other - negotiating their trades in real time using their iPods. Hunters complete Level 2 by successfully negotiating fur trades for at least five European goods. Clerks finish Level 2 by successfully completing fur trades for at least 15 beaver pelts, which results in a profit of five beaver pelts.

Results

Hypothesis 1. Levels of engagement

To determine whether students were equally engaged with each of the hubs in *Play the Past*, we computed completion rates for Level 2 in each hub (Table 1). We hypothesized that the Fur Trade would have the highest level of engagement, because it has roles that promote positive interdependence, collaboration, and individual accountability. Based on this data visualization it is clear that students were more engaged with the Sod House and Iron Mine, but did not fully engage with the Fur Trade hub, which provides evidence against the hypothesis. However, this trend is not present at earlier levels in each hub (Start, Level 1), which means that students have similar levels of engagement across hubs until they reach Level 2.

Table 1. Table of student completion numbers across levels and hubs in Play the Past

	Fur Trade	**Iron Mine**	**Sod House**
Start	6,640	6,968	6,840
Level One	5,772	5,751	5,453
Level Two	3,049	3,916	4,248

Hypothesis 2. Effect of role on engagement

We were able to examine how student roles (Clerk and Hunter) affected engagement levels by further analyzing student behaviors in the Fur Trade hub. Among the 5,772 students who completed Level 1, 3,038 students were assigned to be hunters and 2,734 students were clerks, which is a significantly smaller number of clerks (χ^2 = 16.01, df = 1, p = <.001). Unfortunately, this trend continues where only 1,208 clerks complete Level 2 in comparison to 1,842 hunters (χ^2 = 131.78, df = 1, p = <.001). These findings suggest that there may be an imbalance in the design of the game between roles.

To investigate this trend further, we focused on specific behaviors of students in the Fur Trade. In particular, we focused on their interactions with the trading mechanic. This is the core activity that students must use to complete Level 2. To operationalize trading efficacy, we calculated a trade ratio for each student to reflect their skill at negotiating trades. For example, if a hunter paid 1 beaver pelt for an item that was worth three beaver pelts, the hunter would receive a trade ratio score of 3 for this trade. In contrast, if a clerk were to sell an item that was worth 4 beaver pelts for 1 beaver pelt, they would receive a score of ¼ for this trade. An average of the trade ratio scores was calculated for each player and used as a reflection of their trading skill in the analysis below.

A mixed-effects logistic regression was used to explore the relationship between role, trade ratio, and Level 2 completion rate. There was a significant interaction effect in Model C between Role and Trade Ratio when predicting completion of the levels within the Fur Trade, because Model C had the lowest corrected Akaike Information Criterion (AICc) in comparison to Model A and B (*AICc*: A = 6,301.45, *AICc*: B = 6,025.26, *AICc*: C = 5,968.04). To help interpret these findings, we plotted the predicted probability of completing Level 2 of the Fur Trade (Figure 2). This figure shows that the largest discrepancy in probability of Level 2 completion occurs when students have an average trade ratio between 0 and 2, which results in clerks having roughly 15% lower probability of Level 2 completion than hunters.

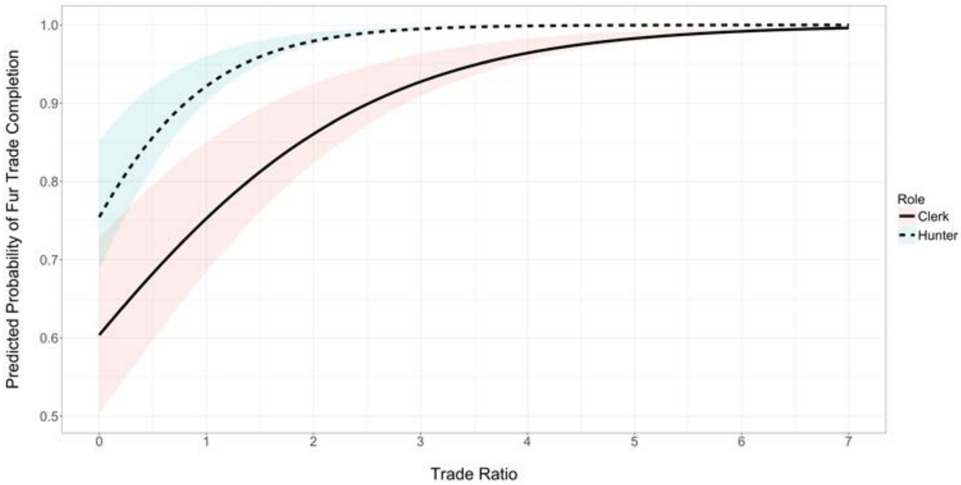

Figure 2. Predicted probability of fur trade completion based on trade ratio by role in *Play the Past*.

Discussion

Based on the findings of this study, it is clear that engagement levels differed between the hubs and levels in *Play the Past*. Students were more engaged with the Iron Mine and Sod House hubs, despite the Fur Trade's design to that had distinct roles that promoted positive interdependence and collaboration. Additionally, our results suggest that the design of the roles employed in the Fur Trade (Clerk and Hunter) do not pose equally difficult challenges. Specifically, the students assigned to be a clerk must trade at a much higher profit margin than students who are assigned to be a hunter, which may impede them from finishing Level 2 or encourage them to quit the Fur Trade and move to the Sod House or Iron Mine. Conversely, students who were assigned the role of hunter, were more likely to complete the Fur Trade than students who were assigned to be clerks. Based on this trend, it is clear that students who had distinct roles were not equally engaged in the game, despite the roles being designed to support collaborative learning by promoting positive interdependence and collaboration, as suggested by Klopfer and colleagues (2005). In addition, these findings suggest that the inclusion of interdependent roles may interact with other game design elements, such as difficulty in ways that are not beneficial to the student experience, and impede collaborative learning within the environment.

Although the findings presented here are rigorous and thorough, there are several limitations. Due to an unfortunate limit on the data that could be collected, there is no information regarding the individual students age, gender, or socioeconomic status. Additionally, conclusions drawn from this work should be modest, because of the use of only telemetry data for this study.

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Maker Portfolios as Learning and Community-Building Tools Inside and Outside Makerspaces

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Abstract: Portfolio assessment gains new traction in youth-serving maker-educational spaces through increased inclusion of maker portfolios in college and job applications. However, the collaborative and cooperative character of making poses a tension to traditional portfolio assessment that is focused on showcasing individual achievements. Together, this calls for an expanded understanding of the use of portfolios in maker education. We examined the types of portfolio entries at two youth-serving makerspaces (one out-of-school and one in-school), and observed the documentation of personal and shared projects in personal and shared portfolios. Our main findings are that, compared to portfolios that focused on personal work alone, portfolios that included shared projects and documentation presented richer showcases, showing technical and social engagement, assessment by people across a distributed community, and possibilities to narrate work to multiple audiences. This has implications on the facilitation of maker portfolios and broadens portfolio assessment to show the role of the learner in society.

Keywords: maker education, portfolio assessment, maker portfolios

Introduction

Youth-serving makerspaces are spaces for learning, in which youth create projects using digital tools and tangible materials alongside their peers. Through design, learners become active producers of sharable artifacts (Peppler, 2013). By making projects publically available and sharing them within the maker-educational spaces, makerspaces become communities of learning that center around the collaborative construction of that community (Sheridan et al., 2014). This combination of design and sharing practices is in many ways similar to Knowledge Building, which sees learning as a production-centered, collaborative, and interest-driven design process that acts as a catalyst for collaboration and communities (Seitamaa-Hakkarainen, 2009). Aspects of the design process center on the use of mediating technologies to document, share, and reflect on contributions toward forming a shared understanding (Hakkarainen, Paavola, Kangas, & Seitamaa-Hakkarainen, 2013).

Documenting, sharing, and reflecting on learning in makerspaces is a promise of digital portfolio assessment. Portfolio assessment originated from the historical precedent of arts-based portfolios (Gardner, 1989). As a response to the increased pressures of accountability, portfolios were seen as a hopeful alternative to standardized testing and a way to provide a richer picture of student learning (Niguidula, 1993; Mills, 1996). Typical portfolio assessment processes tightly couple instructions and assessment to increase ownership over learning and to position portfolios as learning tools (Lamme & Hysmith, 1991; Love, McKean, & Gathercoal, 2004). While traditional portfolio assessment often culminates in one individual student's personal website, narrative, or collection, as students capture their accomplishments and learning processes online, portfolios can also become community-building tools, garnering constructive feedback on expressed efforts (Tseng, 2015). Today, maker portfolios are gaining traction as part of job and college applications, promising to expand access to opportunities beyond the makerspace (Peppler, Maltese, Keune, Chang, & Regalla, 2014). While traditional portfolio assessments have defined audiences, maker portfolios invite multiple audiences that are unknown at the time the portfolio was created. The community-oriented approaches of making and the potential multiple audiences of maker portfolios present tensions to traditional portfolio assessment and suggest that we cannot apply them to maker-education. The expanded role of portfolios as learning tools and community-building tools inside *and* outside of the maker-educational setting calls for a fundamental shift from valuing cognitive outcomes to valuing the role of the individual in society. Educators have to design portfolio practices that act as learning and community-building tools inside *and* outside the makerspace and the new purpose of representing youths' role in society is imperative. This leads us to the question: How do portfolio posts differ across youth portfolios and what kind of posts facilitate portfolios to function as tools for learning community building, and expanding opportunities beyond the makerspace?

The experiences which youth document today could dramatically shape the opportunities that they access tomorrow. Understanding how to successfully capture the richness of engagement in maker-educational settings promises to broaden opportunities, because not only products and individual achievement but also the role of collaboration and community engagement can become visible to people outside the maker-educational space.

Methods

To study youth maker portfolios, we performed a year long qualitative inquiry in two maker-educational spaces with continous space-wide portfolio efforts: an out-of-school and a high school makerspace in the eastern United States. We selected the sites from 10 youth-serving makerspace because both spaces integrated making across subjects and programs and all youth had personal websites for documenting projects, processes and reflections The out-of-school space offered programs to youth from 8 to 18 through summer camps (e.g., 3D printing, digital filmmaking), open-ended programs, and foundational courses. All youth had a personal website that linked to a shared page that showed all current projects. At the high-school space, students documented assignments and work-in-progress on personal websites, and teachers worked with portfolio templates or designed their own approaches to facilitate portfolio processes.

Our engagement began with conference calls with educators and site administrators to get an overview of the makerspace portfolio practices and to plan field site visits. During two field site visits to each site, we observed youth working on portfolios and asked 10 youth to "walk us through" their portfolios, which fused usability walkthroughs (Rieman, Franzke, & Redmiles, 1995) with semi-structured interviews (Merriam & Tisdell, 2015). Here, youth talked about their projects, learning, and reasons for documenting. We also studied the online portfolios of 37 youth (22 from the out-of-school and 15 from the school space), who were recommended by educators as particularly engaged in portfolios. The portfolios included 569 posts in total.

Following Erickson's (2004) approach to qualitative research, we iteratively looked across entries and identified themes within the makers' projects and documentation to help characterize the portfolios in relation to their function as tools for showcasing individual work as well as presenting the role of the individual in society inside and outside of the makerspace. The themes we identified were: (1) personal projects paired with personal documentation, (2) shared projects paired with personal documentation, (3) personal projects that were documented in shared spaces, and (4) shared projects that were documented in shared spaces.

Categorizing the portfolio entries and walkthroughs according to these themes, we identified patterns in the way that social engagement in projects and documentation was represented across portfolios. This highlighted both frequently reoccurring practices and unique portfolios. An in-depth analysis of theme-related portfolios identified how portfolio entries characterized makers' experiences inside the makerspaces as well as some of the opportunities that portfolios may open up for youth outside the makerspace.

Findings

Of the 569 posts reviewed, the majority (81.5%) showed **personal projects paired with personal documentation**. The posts included projects related to 3D printing, game design, and digital image manipulation. When we observed maker activities that were framed as personal projects and captured in personal portfolios, we noticed that youth nevertheless actively crafted together, pointing at or commenting on each other's projects and techniques, while educators facilitated feedback and peer-review activities. The entries acted as learning tools, because youth could revisit them and see their personal progress in technical skills. In addition, the entries served community because the youths' technical explanations could act as guides for similar projects. And finally, outside the makerspace portfolio entries on finished products could elevate college or job applications.

By contrast, **shared projects paired with personal documentation** did demonstrate social practices. Of all posts, 12.6% were of this type. They included personal reflections on small-group collaborations, such as descriptions of prototyping new makerspace furniture within small groups. The portfolios with entries that referenced social interactions during making also contained entries on finished projects and techniques. When youth augmented the documentation of final projects with evidence of social interactions during making, the portfolio showed teamwork development over time, suggesting how an applicant might fit into a new community by showing the youth's role in their community to an outside audience.

The out-of-school makerspace curated all individual youths' portfolios on one website and highlighted the latest entries by each youth on one page (Figure 1). This was an example of **personal projects that were documented in shared spaces.** Youth described this particular page as a tool for learning and community building. Seeing the accumulated work served as a springboard for new projects. As a barometer of community projects, shared documentation of personal projects could provide visitors with insights into the community and the types of projects that individuals have access to as result of their makerspace membership.

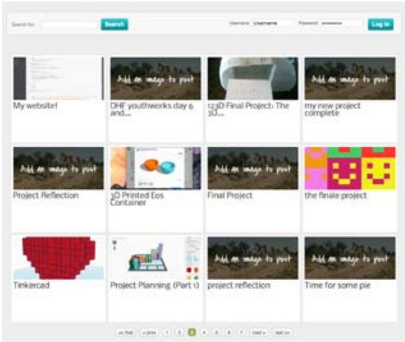

Figure 1. Personal projects that were documented in shared in the out-of-school makerspace.

Shared projects that were documented in shared spaces (e.g., across online platforms) further augmented portfolios. One example of this was Ted's high school maker portfolio. Involved with media production courses, Ted captured his motion pictures on YouTube, including music videos, digital animations, and effects (Figure 2, left). His channel had over 7,000 subscribers. At first glance a personal space for documentation, Ted linked his channel to collaborators and actively called for reviews, which encouraged the building of a community around his work and attracted requests for tutorials on his special effects. In addition, his portfolio included a Soundcloud account, co-owned with a friend, which offered audio remixes they created together. It had more than 19.000 followers (Figure 2, right).

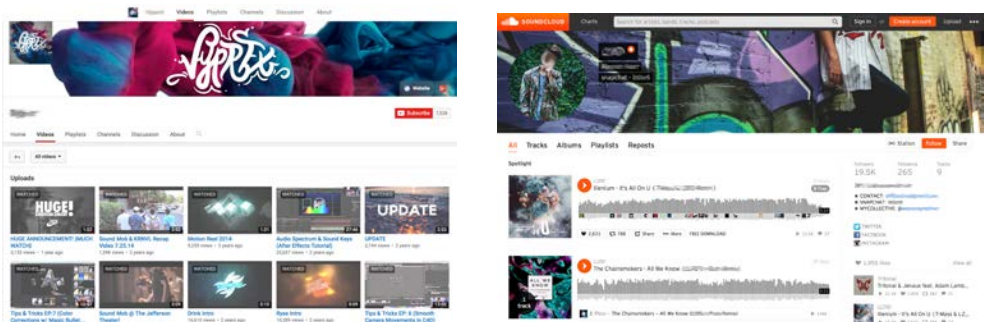

Figure 2. Screenshot of Ted's YouTube channel (left) and Ted's shared Soundcloud account (right).

Ted's distributed body of work supported him in building a strong online presence and a community outside school that was willing to assess his work. While people inside the community and school setting might not require descriptions to understand his work, people outside the community would need such background information. When applying to college, Ted curated his work on a website that had expired when we spoke to him: "For now I've already gotten into college. (...) My portfolio is almost word-of-mouth at this point so people can show other people the things that I've done." Ted was not concerned about the "sketchbook" character of his portfolio, which lacked a unified narrative. The distributed pieces that included shared projects and were documented in shared spaces allowed him to establish himself as an accomplished maker who engaged people across communities, and to spin-off narratives when needed.

While all portfolios allowed youth to present products and processes to an audience, different types of portfolio entries painted different pictures of engagement. Individual making paired with individual documentation privileged the presentation of final projects and technical processes, which could potentially promote a youth's job or college application. Shared projects captured in personal entries augmented final projects and techniques with displays of social engagements, which could help employers or college boards imagine how prospective candidates might fit into a workplace or college culture. Personal projects documented in shared portfolios further expanded portfolios to give insight into the community for external reviews. Even further augmentation occurred in portfolios that included shared projects and shared documentation, which facilitated the engagement with communities outside the makerspace and challenged portfolios as unified narratives. Although a majority of the posts and portfolios included personal rather than group projects, we found that portfolios that included diverse types of entries led to a strong online presence and community participation. Compared to portfolios that focused on personal work alone, portfolios that included shared projects and documentation presented richer showcases, showing technical and social engagement, assessment by people across a distributed community, and possibilities to narrate work to multiple audiences.

Discussion and implications

Few projects and documentations reviewed in this study captured collaboration, yet group projects and shared documentation had a strong visible impact on the community outside the makerspace. Our findings have implications for the design of portfolio processes and assessments. They point to the importance of facilitating collaboration in creating projects *and* documentations and encouraging adaptive sketchbook portfolios over unified narratives. However, the fact that portfolios did not show collaboration does not mean youth did not collaborate. Through shared projects and shared documentation, the youths' roles inside and outside of the makerspace can be encouraged and made visible, broadening portfolio assessment beyond capturing knowledge and skills. This pushes our understanding of the role of portfolios as tools for assessment toward evidence of the role youth play in society. Furthermore, adaptive portfolios could be curated more readily into different emergent narratives, which could broaden opportunities for youth to frame their experiences to unanticipated audiences after capturing portfolio entries. Overall, the findings point to the importance of considering collaboration in making and documenting when designing portfolio assessments that are intended to serve as learning and community building tools inside and outside the makerspace. Future work should focus on identifying specific facilitation strategies for collaboration in making and documenting as well as investigating the implications of the online availability of shared and potentially conflicting accounts of youth creative experiences, for example through the study of youth creative processes within online portals (e.g., the Scratch community).

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Videoconferencing in Peer Review: Exploring Differences in Efficiency and Outcomes

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Abstract: Technology-mediated communication, such as teleconference and videoconference, has been found to affect group decision-making processes compared to face-to-face settings. Scientific peer review panels offer a site of authentic, collaborative decision making among expert scientists, yet no research has examined the impact of videoconferencing on such decision-making practices. We assigned real, de-identified grant applications submitted to the National Institutes of Health (NIH) to four panels of experienced NIH reviewers, one of which met via videoconference. The videoconference panel was slightly more efficient than the face-to-face panels, but the outcomes of their decision making (i.e., the scores assigned to grant applications) did not differ. However, preliminary analyses suggest there are differences in the *nature* of the collaborative discussion among reviewers between the two meeting formats. We discuss implications for research into technology-mediated collaborative decision making, as well as for the scientific grant peer review process broadly.

As research budgets tighten, funding agencies are seeking ways to reduce the costs of conducting grant peer review meetings (Bohannon, 2011), including the use of peer review panels conducted via teleconference and videoconference (Gallo, Carpenter, & Glisson, 2013). Decades of research (e.g., Bly, 1988; Driskell, Radtke, & Salas, 2003; O'Conaill, Whittaker, & Wilbur, 1993; Walther, 1997; Whittaker, 2003) investigating how the use of such technologies alters the ways in which people interact—particularly during problem-solving or decision-making tasks—suggest that virtual teams may function categorically differently than in-person teams (Andreev, Salomon, & Pliskin, 2010; Kiesler & Cummings, 2002; Kraut, Fussel, Brennan, & Siegel, 2002; McLeod, 1992; Straus & McGrath, 1994). However, there is not a consensus regarding whether technology-mediated communication is fundamentally different from in-person communication (Doherty-Sneddon, et al., 1997; Olson, Olson, & Meader, 1995). Given these discrepant findings, examining whether videoconferencing impacts the grant peer review process and whether it can serve as a viable alternative to traditional face-to-face peer review is of crucial importance, since grant peer review is the key mechanism by which precious research funds are allocated to scientists to conduct their research. This study stands to make an original contribution to our understanding of the mediating effect of technology not only on how expert scientists engage in collaborative decision making, but also on the outcomes of the scientific peer review process itself.

Theoretical framework

Technology-mediated communication (TMC), including the use of teleconferencing or videoconferencing, has been found to affect group decision making. For example, compared to face-to-face (FTF) settings, researchers have found the use of TMC to increase difficulty in achieving consensus (Sellen, 1995), in managing turn taking (Anderson et al., 1999; O'Conaill et al., 1993; Tang & Isaacs, 1993), and in establishing mutual understanding (Clark & Brennan, 1991; Thompson & Coovert, 2003). In particular, Cramton (2001) found that TMC negatively impacts the ability of groups to establish common ground during tasks in which team members possess unique information (i.e., when knowledge or expertise is distributed, as it is during grant peer review). This negative effect is further exacerbated when the task is more complex, involves a higher workload, and requires group interdependence—all of which are features of grant peer review.

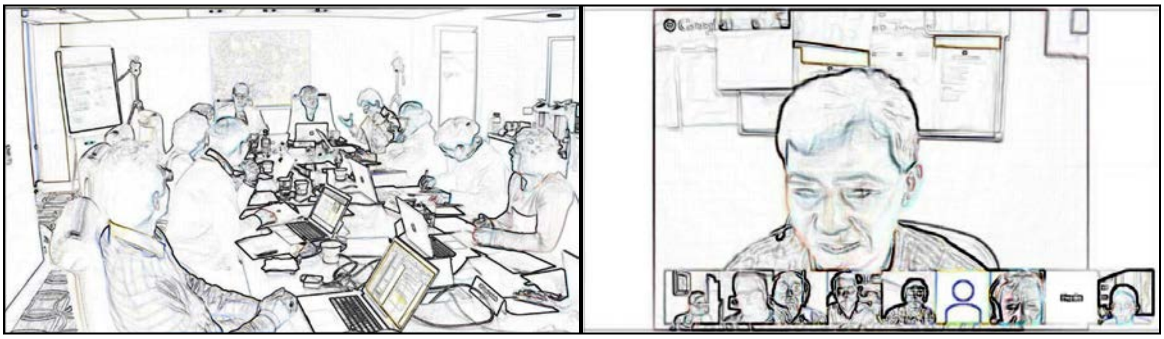
Given the time-consuming nature of peer review meetings, questions of efficiency tradeoffs are particularly acute. Although some researchers have found that computer-mediated meetings are shorter and more efficient than FTF meetings (e.g., Denstadli, Julsrud, & Hjorthol, 2012; O'Connaill et al., 1993; Tang & Isaacs, 1993), other scholars have found that TMC decreases task efficiency and increases the time to reach consensus (e.g., Doherty-Sneddon, et al., 1997; Straus & McGrath, 1994; Whittaker, 2003). Beyond mere efficiency, prior research suggests that TMC can reduce productivity and effectiveness in accomplishing tasks (Andreev et al., 2010; Kiesler & Cummings, 2002; Kraut et al., 2002; McLeod, 1992). Thus, it is an open empirical question as to whether TMC increases or decreases efficiency in peer review panel meetings, as well as whether it affects the outcomes of the decision-making process itself.

Much of the work examining the effect of TMC on group decision making has been done in lab settings (Anderson, McEwan, Bal, & Carletta, 2007; Whittaker, 2003), with "relatively little detailed empirical evidence on the impact of different forms of multimedia communication on patterns of communication in the workplace" (Anderson et al., 2007, p. 2560) and "few studies [that] have explicitly compared the way videoconferencing and face-to-face meetings are used in modern organizations" (Denstadli et al., 2012, p. 86). Only one study to date (Gallo et al., 2013) has investigated the role of TMC in peer review specifically; the authors found few differences between face-to-face and teleconference grant peer review except for a small difference in overall discussion time. Yet, no studies to date have examined the role of videoconferencing in peer review, despite the fact that it is a format increasingly used by many funding agencies (Bohannon, 2011). This study aims to fill this gap in knowledge by posing three questions that make a preliminary attempt to explore the role of TMC in grant peer review: (RQ1) Do FTF and VC peer review meetings differ in efficiency? (RQ2) Do FTF and VC meetings differ in their outcomes (i.e., the scores they assign to grant applications)? (RQ3) Do FTF and VC meetings differ in their collaborative scoring processes?

Methods

The research team recruited biomedical scientists with experience reviewing for the National Institutes of Health (NIH) to participate in one of four peer review panel meetings—three conducted in person (FTF), and one conducted via videoconference (VC). Figure 1 is an anonymized screenshot from video of (a) one of our FTF meetings and (b) our VC meeting. Reviewers evaluated de-identified applications previously reviewed by real panels within NIH's National Cancer Institute between 2012 and 2015. We solicited Principal Investigators (PIs) using NIH's public access database, *RePORTER*, to donate applications that were either funded or not funded on the first submission. Each panel had between eight and 12 reviewers who evaluated six applications apiece, with three reviewers assigned to a given application in each meeting. Based on the three reviewers' preliminary scores, the top 50% of applications were discussed in a given meeting, with the bottom 50% triaged out from discussion (as is typical in NIH peer review), so that each panel discussed between eight and 11 applications depending on the number of participating reviewers.

Our meetings were designed to follow the norms and practices of actual NIH peer review in all aspects of study design, and all methodological decisions were made in consultation with staff from NIH's Center for Scientific Review and with a retired Scientific Review Officer (SRO), who assisted with recruiting reviewers and chairpersons, assigning reviewers to applications, and overseeing each meeting. For a detailed description of the methods used to design the meetings, see Pier et al. (2017).



(a) (b)

Figure 1. De-identified screenshots of one FTF meeting (a) and the VC meeting (b).

To answer RQ1, we measured the amount of time spent discussing each grant application in each meeting, beginning at the moment the chairperson introduced the grant to be discussed, and ending when the chairperson introduced the subsequent grant to be discussed. To answer RQ2, we compared the panels' final scores for each application. To answer RQ3, we examined the degree to which reviewers' scores changed as a function of collaborative discussion.

Results

For RQ1, we found that on average, the videoconference meeting was the most efficient meeting in terms of average time spent per application (Table 1). Panelists in the VC meeting spent 2 minutes and 18 seconds less, per application, on average compared to the three FTF meetings. However, for RQ2, we found that the VC meeting did not perform much differently from the FTF meetings in terms of the scores they assigned to applications (Table 2). At NIH, panel scores range from 10 (best) to 90 (worst) and constitute the average of all panelists' scores following collaborative discussion. On average, the videoconference panel assigned similar scores to their pool of applications as the FTF panels (although the first FTF panel stands apart as slightly harsher overall, since the average score was higher, i.e., worse). Importantly, for RQ3, we found that reviewers in the VC panel changed their scores during the meeting as a function of collaborative discussion less frequently (no change 55% of the time) than the FTF panels on average (no change 37.5% of the time), and they worsened their scores less frequently (30% of the time) than the FTF panels on average (52.1% of the time). Therefore, although the scores themselves do not appear to differ between the formats overall, the patterns of score changes suggest there are differences in the nature of the collaboration in FTF versus VC panels.

Table 1: Average time spent (minutes:seconds) discussing applications

FTF 1	FTF 2	FTF 3	FTF Average	VC	Total Average
M = 14:52 *SD* = 1:54	*M* = 16:17 *SD* = 6:07	*M* = 17:18 *SD* = 3:40	*M* = 16:09 *SD* = 4:15	*M* = 13:51 *SD* = 3:26	*M* = 15:48 *SD* = 3:59
Note. FTF 1 = Face-to-Face Panel #1, and so forth. VC = Videoconference Panel.					

Table 2: Average final panel scores in each meeting

FTF 1	FTF 2	FTF 3	FTF Average	VC	Total Average
M = 38.3 *SD* = 10.1	*M* = 32.3 *SD* = 5.5	*M* = 31.5 *SD* = 8.7	*M* = 34.0 *SD* = 8.6	*M* = 31.6 *SD* = 7.1	*M* = 33.4 *SD* = 7.5

Table 3: Number (and percentage) of times reviewers changed their scores during the meeting

	FTF 1	FTF 2	FTF 3	FTF Average	VC	Total Sum
Improved score	2 (6.3%)	3 (9.7%)	5 (15.2%)	3.33 (10.4%)	3 (15.0%)	13 (11.2%)
No change	7 (21.9%)	16 (51.6%)	13 (39.4%)	12.0 (37.5%)	11 (55.0%)	47 (40.5%)
Worsened score	23 (71.9%)	12 (38.7%)	15 (45.5%)	16.67 (52.1%)	6 (30.0%)	56 (48.3%)
Sum	32 (100%)	31 (100%)	33 (100%)	32 (100%)	22 (100%)	116 (100%)

Discussion and conclusion

We found that there was an efficiency gain for the videoconference peer review meeting over the three face-to-face meetings, which aligns with prior research finding that TMC meetings are shorter and more efficient (Denstadli et al., 2012; O'Connaill et al., 1993; Tang & Isaacs, 1993). This may be due to less discussion time in VC formats stemming from fewer turns of talk, in part due to the heightened barrier to entry into conversation that videoconferencing introduces. Importantly, we found that the efficiency gain of the VC panel was not accompanied by a noticeable difference in the average final scores that the panels assigned to applications. Thus, despite the complexity of the task and the distributed nature of reviewers' expertise, TMC may not hinder a group of expert scientists as they engage in grant peer review, echoing Gallo and colleagues' (2013) finding regarding the use of teleconference peer review meetings (cf. Cramton, 2001). Utilizing videoconferencing to conduct peer review meetings may thus offer a reasonable solution to funding agencies' tightening budgets.

However, our preliminary investigations into the *process* by which reviewers arrive at the final scores suggest that there are some differences in the VC format necessitating further examination. We found that reviewers in the VC meeting changed their scores less frequently than reviewers in the FTF format, and that they worsened their scores less frequently than the FTF panels; this implies there may be differences in the collaboration among panelists in this format resulting in less frequent score change, and less score change of a critical nature. Our future work plans to examine how turn taking unfolds in each panel meeting, to quantify the number of unique contributors to each discussion, and to explore the decision-making strategies each panel employs to achieve consensus.

This short paper offers descriptive insights into our expanding and evolving understanding of how technology-mediated communication affects collaborative decision making in various contexts. Given that this is an exploratory pilot study restricted to a single VC panel, it is limited in its generalizability beyond our sample. Furthermore, lack of random assignment of applications and of reviewers precludes any causal claims. Nevertheless, this work presents preliminary findings from our data that will guide our future research. Given the importance of grant peer review for the enterprise of science as a whole, and that many funding agencies are increasingly conducting videoconference peer review meetings, understanding how the use of videoconference may change the process and outcomes of peer review is of paramount importance.

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Self-Organizing Collaborations as Blueprints for CSCL Design

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Abstract: We propose that ethnographic studies that precede, but inform, design, can be a productive addition to CSCL design practices. We anchor our claims in a case example of an ethnography of an undergraduate history course. We describe how the ways in which learners self-organized and created practices for producing, sharing and reproducing knowledge in the course can serve as a blueprint for CSCL design. Such learners' counterculture practices may not readily emerge in participatory design discussions. This approach identifies points of contact between pre-existing collaborative practices and pedagogical considerations. Designers can then infuse pedagogical innovations into the activities that participants already value and perform, achieving benefits akin to participatory design.

Introduction

Considerable research in CSCL analyzes the ways in which designed technological supports enable groups of learners to develop knowledge and skills through joint activity (Dillenbourg, Järvelä, & Fischer, 2009). Increasingly, it also includes designing ways in which the tools can be integrated within the structures of local settings (Cress, Stahl, Ludvigsen, & Law, 2015; Roschelle, Dimitriadis, & Hoppe, 2013). In this paper, we take the local setting as our starting point, and investigate how naturalistically occurring collaborations can serve as a blueprint for CSCL design. Specifically, we report on a cognitive ethnography of an introductory undergraduate history course. We describe how the ways in which learners self-organized and created practices for producing, sharing and reproducing knowledge in the course inform our design. We propose that basing designs on findings from ethnographic studies can, just like participatory design (Könings, Seidel, Jeroen, & van Merriënboer, 2014), mitigate some of the challenges associated with the introduction of externally designed tools.

The need to incorporate local voices into CSCL design

Research in the learning sciences, and in CSCL specifically, often envisions new forms of learning that can cultivate more robust knowledge and skills (Barab, 2014; Design Based Research Collective, 2003; Dillenbourg et al., 2009). Turning these visions into a reality has to do with embodying the vision in a design (Sandoval, 2013), but even more so, it is dependent on whether and how the design in taken up by local participants (Dillenbourg et al., 2011; Radinsky, Loh, & Lukasik, 2008; Suchman, Blomberg, Orr, & Trigg, 1999).

CSCL tools may support learners in the sense-making process, but learners may not have social structures in place that enable them to make effective use of these features (Fischer et al., 2013). Determining what medium can best support a process may be a function of the interplay between the qualities of the medium and of the setting. For example, some information may be adequately represented in either digital or paper form, but paper might work better in some settings (Dillenbourg et al., 2011; Smith & Reiser, 1998). A large sheet of paper laid out on the floor can enable a group of children to cluster around the sheet, mark it up; pick it up and lay it next to another group's sheet; argue about similarities and differences while motioning or covering parts of the drawing with their hands or body; then, pin-up their drawing and proceed to create a new version that will be pinned up next to the first drawing. In this example, the collective interaction with and around the drawing was better supported by the paper, aligning with routinized practices in the classroom, and enabling learners to pin-up a series of drawings as a "thinking trail" (Johnson, 1997). As in this example, local participants may have pre-existing practices that fulfill some of the same learning goals as the proposed designs, or may have pre-existing practices that can augment and strengthen the designed supports (Tabak, 2004).

These examples point to the need to understand how participants might perceive particular tools, how local settings are configured, what needs are particular to the setting, and what are the existing material and social practices that sustain intellectual work. These insights should inform the design. As a result, there are increasing efforts to incorporate local voices in various design processes, including CSCL design. Incorporating local voices in the design process takes on different forms, such as, design-based research (e.g., Barab, 2014; Roschelle et al., 2013), teachers as designers (e.g., Kali, McKenney, & Sagy, 2015), participatory design (e.g., Könings et al., 2014), change laboratory (Engeström, 2007), and ethnographic study (e.g., Suchman et al., 1999).

Ethnographic study that precedes any design or intervention, is less common in the CSCL community. In this paper, we want to make a call for increased attention to this approach. We suggest that it holds particular value for educational contexts in its potential to strengthen learners' voices in the design, and in facilitating designs for third space (Gutiérrez, Baquedano-López, & Tejeda, 1999). Suchman, Blomberg, Orr and Trigg (1999), in their retrospective of 20 years of research, note that in the absence of ethnographic study some aspects of practice may remain outside the purview of the design process, because participants may not raise in discussion aspects of practice that are so ingrained that they seem "unremarkable." Based on our own ethnographic findings, which we discuss further below, we proffer that power relationships and the social construction of various practices as "worthy," "unworthy," "script," or "counterscript" (Gutiérrez et al., 1999) might further stand in the way of participants voicing certain practices in design discussions. Consequently, practices that could contribute to the design and to its productive take up by participants might remain outside of the design process.

An example of an ethnography informing CSCL design

We conducted a cognitive ethnography (Hutchins, 2014) of an introductory undergraduate history course in an Israeli university. The study included weekly observations of class and recitation sessions, as well as in-depth interviews with the course instructor, teaching assistant, and a sample of students. The ethnographic study (Brami, 2015) revealed qualities of the formal and of the unofficial social spaces of the course. Following Gutierrez and colleagues (e.g., 1999), these are referred to, respectively, as the *script* and the *counterscript*. The counterscript enabled many of the students, even those who were mostly disengaged from the formal script, to pass the course. More significant from our perspective was that some of these counterscript practices could potentially be leveraged for the purposeful design of a third space (Gutiérrez et al., 1999) in which the script—infused with supports for disciplinary epistemic socialization (Tabak & Reiser, 2008; Tabak & Weinstock, 2011)—could productively coalesce with the counterscript.

Self-organizing collaborations

The script in this course was similar to many large undergraduate introductory courses, where the central conduits for knowledge are the course lectures and course readings. There were students who did not attend the lectures, did not read the required readings, or attended lecture but were not necessarily attentive. On the surface, it might seem that these students were disconnected from the intellectual life of the course, destined, perhaps to fail. Yet, uncovering the counterscript, revealed that the students in this course had established a parallel intellectual life that engaged in conversation with ideas from the script. In this counterscript, the main conduits for knowledge were shared course notes, and an archive of past exam questions and model answers. It is through this counterscript that the majority of students engaged with the intellectual content of the script, and this enabled them to contend with the final exam. We focus here on the note taking practices.

Students organized and sustained a collaborative system for shared notes. The shared note taking enterprise took on various forms with different students fulfilling different roles. One form of collaborative note taking was a more insular collaboration among a group of students. The notes produced by this group were shared within the group but not with the entire course. In this group, some students were note takers, tasked with summarizing the main points from class, while others in the group were responsible for reading and summarizing the assigned reading. The more prevalent collaboration was the voluntary posting of class notes that were made available to any student in the course. A few students in the class took notes at their own initiative, and chose to post their notes to the course Facebook group or Dropbox folder. The majority of students in the course were consumers rather than producers of these notes.

This "consumption" of notes was strategic: some note takers had a reputation for consistently producing accurate extensive notes, and their notes were more highly consumed. These reputations sometimes transcended courses, because the voluntary posting of class notes to a shared cloud was a common practice in many courses. Students held the shared notes in high regard, considering them essential to their learning and their ability to succeed in the course (which essentially meant to perform well on the final exam). In fact, the "master note taker" in the class we observed was highly valued, and one student said that her friend recommended his notes, stating that he was "her angel, her savior," and that he had already "saved" her on two exams (courses).

Blueprints for CSCL design

Our research program focuses on designing material, technological and social supports to cultivate disciplinary practices. We had a number of design features in mind based on published literature and our prior research. However, the cognitive ethnography of our target setting, undergraduate history education, pointed us in additional directions that we had not considered previously. We saw students' pre-existing practices as an opportunity to infuse disciplinary considerations into a set of practices that students valued, and in which they were already immersed. Thus, one main facet of our (in progress) design is a collaborative note taking tool, that includes prompts and other structuring features derived from a task model of expert historical reasoning. In what follows we discuss two main points of contact between our pedagogical aims and students' counterscript practices.

Capitalizing on pre-existing collaborative structures

One of the challenges in reaping the pedagogical benefits of CSCL innovations is that students are not always attuned to productive collaborative processes, creating a need to support the process of collaboration as well as the domain processes that the tools were designed to support (Fischer et al., 2013). In this case, the cognitive ethnography revealed pre-existing collaborative processes. Rather than introduce an innovation that calls for a new social organization that will require its own set of supports, we are infusing supports into these existing collaborative structures. Similarly, the pedagogical supports will be embedded in artifacts and practices that are already valued by the students, and that are part of their conception of productive course participation.

Bolstering nascent spontaneous disciplinary practices

The students' note taking enterprise offers a promising opportunity to cultivate core disciplinary practices, because the "master notes" already, spontaneously, reflect such practices. In our analysis of the content of the "master notes" we found that the master note taker would annotate the notes with comments that pointed out connections between prior notes and current notes, between the course readings and the notes, or pointed out how particular elements in the notes explicate a key idea in the lecture/historical work.

In many ways, the master note taker's annotations express reflective processes and historical reasoning (e.g., Wineburg, Martin, & Monte-Sano, 2014), as well as a recognition of the, sometimes subtle, messages that the instructor conveys about history and historical work. One example comes from a set of notes related to a lecture on a critique of the decline thesis approach to Ottoman historiography. The lecturer raises a rhetorical question asking learners to consider what underlies the moniker "Suleiman the Magnificent" noting that the Ottomans referred to Suleiman as "the legislator." The master note taker rewrites this rhetorical question as a statement in an annotation to the notes, writing that "Suleiman the Magnificent" is a *moniker* that was *given* with the decline thesis, the Ottomans *called* him "the Legislator" (translated from Hebrew, emphasis added, sic). We take this annotation to reflect the note taker's recognition that the use of the term "magnificent" is a form of positional writing, it is part of a particular way of portraying events as a rise and fall. It further connotes that historical accounts can be evaluated against evidence, such as the existence of the moniker "the Legislator."

These notes are more than a testament to one learner's prowess, they are indicative of broader understanding. Many students held these notes in high regard due to their added layer of annotations beyond the lecture summary. This means that a larger group of students have enough insight into what counts as history, or what is important in historical work, to recognize the value of these annotations, even if they do not have the ability or inclination to generate them themselves. From a design perspective, this suggests that students are likely to gravitate to notes that include a more elaborate and refined version of such annotations.

Conclusion

There are a number of approaches for shaping designs according to participants' knowledge and practices (Engeström, 2007; Könings et al., 2014; Suchman et al., 1999). Preceding the design process with an ethnographic study can reveal practices that might not arise through design discussions. Particularly in instructional settings, it can reveal practices that reside in the social space occupied by learners. Learners participate in this space willingly and centrally. This space, the counterspace, may include practices that align with formal educational aims. Infusing these existing counterscript practices with pedagogical innovations can create a third space in which learners engage in practices that they value and are accustomed to, while being better supported in achieving formal educational aims. Thus, this approach can strengthen the students' perspective in the design. These ethnographies complement rather than obviate participatory design processes, especially those that include learners in the process (e.g., Könings et al., 2014; Luckin et al., 2006), by extending opportunities for counterscript practices to be part of the participatory design process. Despite its productive potential, infusing pedagogical innovations into counterscript practices also carries a measure of risk. It is highly relevant that the notion of third space originates in scholarship on the tensions that arise from having a new culture *imposed* on one's own (Bhabha, 1994). This tension can lead to alienation and dissent or to the formation and adoption of new hybrid practices. The efficacy of the design, and its ability to make stronger strides in fostering disciplinary practices than in unproductively disrupting student life will need to be put to empirical test.

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CSCL and Vocational Education:
A Bond Worthy of Investigation?

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Abstract: Vocational education and training (VET) is tasked to develop its practices to enhance learners' collaboration skills. Collaborative technologies play an increasing role in initial VET. This paper presents a systematic review on the use of CSCL in initial VET. Starting from an initial set of 823 papers, identified in major databases, each paper was coded by multiple researchers to identify demographics (sample sizes, countries, work domains), methods (data sources, technology design) and outcomes (analysis, forms of collaboration). Finally, only 26 papers met our selection criteria, which illustrates that CSCL research is dominated by K-12 and higher education contexts, while vocational learning contexts are under-represented in this field of study. This observation spurs the question if there is anything unique in VET worthy of being investigated through a CSCL framework. Our analysis hints at a positive answer to this question, both for technological and collaborative components.

Introduction

Vocational education and training (VET) must meet the challenge that future workers need to have a broad range of skills. Stamm (2007) showed how vocational learners are qualified for professional life as they hold "practical intelligence", which includes both specialized knowledge in the professional domain and its application into practice. Practical intelligence articulates technical, specific, practical skills to "personal characteristics - like reliability, willingness to take responsibility, social skills, ability to participate, team work/player, emotional intelligence, intuition" (Strahm, 2016, p. 43) and therefore constitutes a key factor to comply with the needed qualifications for labour market.

The global workplace is changing radically (OECD, 2012; Hämäläinen, De Wever, Nissinen & Cincinnato, 2017). In parallel with rapid changes in contemporary work environments, initial VET (undertaken before or upon first entering work life) is required not only to support the development of professional knowledge (i.e. specific content-knowledge on e.g. marketing, nursing, or electrical engineering) but also to prepare students for their future working lives (European Commission, 2013). Collaboration has always been an important element of learning and working. However, what has changed is the extent to which modern society and global working life requires collaboration skills, particularly in technology-enhanced environments. As a direct result of these changes, VET is under pressure to develop its practices to enhance learners' collaboration skills. This raises the question about how the CSCL society responds on VET needs to meet the challenge of developing and improving a broad range of collaboration skills needed in working life.

In view of preparing future workers for their jobs, using technology-enhanced learning can be an important driver. One the one hand, technology allows to bring more practice in the training of VET students. Especially in dual systems combining school-based and company-based tracks, technology can be exploited to reduce the gap that learners often perceive among learning locations (Taylor & Freeman, 2011; Eteläpelto, 2008). On the other hand, technology can be used to support collaboration, together with the application and practice of the abovementioned practical intelligence skills and attitudes. Specific models to exploit both these affordances of technology in vocational education have been elaborated recently (Schwendimann et al. 2015). Therefore, it seems that computer-supported collaborative learning (CSCL) may hold some promises for VET. So far, however, there is no comprehensive review of studies on CSCL in VET.

Aim of the study

Given the lack of a comprehensive review on the topic, the aim of this paper is to provide a systematic review of studies that are focusing on CSCL within an initial VET context. More specifically, the following research questions will be investigated:

- What are the demographics of the selected studies on CSLC and initial VET (sample groups, countries, work domains)?
- What research methodologies were used in the selected studies on CSCL and initial VET (type of study, data sources, focus on outcomes and/or processes, framework, actors and interactions, and technology design and usage)?

Method

We have conducted a systematic literature review to answer these research questions. The review consisted of several phases. In a first phase, papers were gathered by searching seven databases (Scopus, ISI Web of knowledge, LibHub, ERIC, Proquest, ISTOR, and Sciencedirect) and Google scholar with the search query [collaborat*] AND [VET OR vocational OR education OR training] AND [technolog* OR online OR web-based OR computer*]. Whenever possible, searches were restricted to peer-reviewed paper. In total, 823 papers were gathered based on matches with the title, abstract, or keywords of the paper.

Next, all 823 papers were evaluated based on their abstracts. Papers were excluded if there was no indication that the study was on (1) VET, (2) collaborative learning, or that the study had (3) empirical results and adequate descriptions of their methodology.

The remaining 189 papers went through a second screening in which two coders independently decided for inclusion or exclusion based on the three criteria described above, together with a fourth criterion: a focus on initial VET. Studies that focused on professional development, including, amongst others, teacher training or medical training, were excluded. Disagreements between coders were resolved with the help of a third researcher.

In total, 84 papers remained for full-text analysis. Of those, 55 were excluded after analyzing the full-text version (again with the same procedure: Two independent coders, one extra coder when they disagreed). Finally, 26 papers remained, which were now analyzed in detail, with respect to the number and nature of the participants, work domain, research method, data collection, focus of analysis, theoretical framework, specific technologies used, type of technology, and novelty (see the full list of papers here: http://dx.doi.org/10.6084/m9.figshare.4203333.v3).

Results

Overview and background of the studies

To provide an overview of the background and demographic of the reviewed studies, we focused on the amount of studies found, their sample sizes, work domains, and country context. First, we were surprised that only 26 articles, out of 823, met the criteria for reporting empirical evidence for initial VET and CSCL and thus were included in our review.

Second, when having a look at the sample sizes, results show that most (n=21/26) studies were rather small-scale. Twelve studies had less than 50 participants, while nine had between 50 and 100 participants. Four studies reported findings on a sample between 100 and 200. Only one study included more than 200 participants.

Third, there is a large imbalance in the geographical distribution of the papers. Most papers have been produced in Finland (10 studies; 39%) and Switzerland (8 studies; 31%). The contributions by Swiss researchers can be traced back to an extensive national funding program supporting studies on technology enhanced learning in initial VET contexts. In addition to this, most studies focused only on one country (25 papers), taking country-specificities into account. Only one paper included multiple countries, but not as a comparison (Hämäläinen & Cattaneo, 2015).

Fourth, with respect to the work domains, the most frequently studied work domains were 'business administration' (15%) and logistics (12%). Other frequently studied professions included construction and planning (each 8%). Only one study each referred to woodworkers, electronics, administration, health, and information technology. It is noteworthy that most studies did not investigate a specific profession: Six studies (23%) referred to 'general studies', while 20% reported findings from multiple professions.

Methodologies and focus of the studies

Our analysis of the types of studies and their data indicated that about two thirds of the reviewed papers were case studies (n=18). This means that only about one third of the papers reported on (quasi-)experimental studies (n=8). When examining the data collection methods, the three most popular methods were questionnaires (n=15), video (n=13), and artefacts (n=8). Other forms of data collection included fieldnotes (n=7) and pre/post-tests (n=7), as well as log data (n=6) and interviews (n=6). Most studies (n=18) combined multiple forms of data collection. Related to this, most studies focused on describing and analyzing learning processes only (n=13), while six studies focused on the outcomes (e.g. learning gains) and another seven studies included both processes and outcomes.

Second, we investigated the theoretical frameworks of the studies. The most frequently reported frameworks were ‘scaffolding’ (including ‘scripting’ and ‘orchestration’, n=20) and ‘game-based’ learning (including ‘gamification’, n=11). Other reported frameworks were ‘boundary crossing’ (n=5) and ‘reflection’ (n=4) as well as ‘peer tutoring’, ‘self-regulation’, ‘problem-based learning’, and ‘community of practice’ (each n=3). It is important to notice that two studies used only one framework; 13 studies used two frameworks, and 7 studies combined more than two frameworks. Four studies did not refer to any specific framework.

Third, when considering the actors and interactions studied, we found that the majority of studies focused on students (n=16) and two studies focused only on teachers. Eight studies included both teachers and students in their analysis. Similarly, most studies focused on collaborative student-student interactions (n=26), eight studies on student-teacher interactions, and only one study included student-supervisor - the supervisor is the learner’s trainer within the company - interactions. Given the importance of workplace-based learning in vocational education, it is surprising that there was only one study that included the role of supervisors.

Fourth, we explored the use of technology. When dealing with the application of vocational learning in CSCL, a distinction can be made between the design of new technologies to support learning and the use of existing technologies. In this respect, 10 studies made uses of existing technologies to enhance vocational learning and 16 studies presented novel technologies for enhancing learning in vocational contexts. The two most frequently used forms of collaborative technology were serious games (n=10), typically based on authentic workplace situations and applied to learning holistic work processes and online learning platforms (n=8). Other technologies were tangibles (n=4) and blogs/wikis (n=3). One study did not specify any specific technology as students accessed a range of different online sources.

Discussion

This paper aimed at investigating the current state-of-the art of CSCL research in the context of initial VET. One of the first findings that catches the eye is that there is not a large amount of studies within the field of CSCL that focuses on initial VET. One important conclusion of our research is therefore that VET remains an under-researched field of study. Our final corpus included only 26 papers, most of which (more than 60%) originated from two main research groups in Finland and Switzerland, which is partly due to the availability of specific funding programs. The research focus of these two groups from Finland and Switzerland also affected the selection of professional domains, which are otherwise scattered across a wider spectrum. Additionally, the foci of the included studies are diverse with respect to their design, research methods, data collection, and focus of analyses. They are also scattered with respect to the underlying theoretical frameworks. It is also surprising, given the focus on collaborative learning technologies, that only six out of 26 studies analyzed log data. To summarize, the finding that the combination of CSCL and initial VET is hardly found in research is striking, as there are many opportunities for studying CSCL in the VET context, especially given that it is generally agreed that collaborative skills and technologies are increasingly important at the workplace and particularly in initial VET.

On one hand, there seems to be a general agreement that initial VET is an interesting field of research with implications both for educational and professional contexts. However, the CSCL community seems to have just started to notice the potentials of this line of research. This led us to the question if there is anything distinct about initial VET worthy of investigation from a CSCL research perspective. Based on our data, a first hint to answer this question comes from the analysis of the technologies used across the studies and their intersection with the model of collaboration and the kind of expected outcomes. This latter aspect is probably the most VET-specific variable, given the aim to improve the skills and attitudes required by the labor market, and within them the strong emphasis on collaborative skills.

In this sense, three patterns emerge from the reviewed studies. A first pattern refers to collaborative writing-to-learn, where writing was used to foster scaffolded reflection on one’s and peers’ professional experiences and to exchange views and advice with peers. Existing technologies like blogs and wikis were used to test the effectiveness of specific pedagogical scenarios where the content was specific to the profession involved and aiming at developing declarative as well as procedural professional knowledge in the domain.

A second pattern concerns gamification. Simulations and game-like solutions offered quasi-authentic ways to practice different socio-cognitive collaboration skills, starting from problem-based situations which involved interactions with peers and required the contribution of each group member to be solved. In this case, novel, discipline-specific virtual environments were built to practice work situations that would otherwise be impossible or very expensive to arrange. The environments allowed enhancing both discipline-independent and discipline-specific vocational skills and attitudes.

A third pattern describes the use of ad-hoc developed technologies integrating tangible objects and augmented reality. Similar to game-based learning, the learning activities were mostly based on collaborative problem-solving tasks. This is the most specific pattern, as both technologies are specific to the needs of the target professions. Content and skills are context-dependent and not transferable to other professions. In this sense, this can also be seen as the most VET-specific implementation of CSCL.

Additional insights come from considering collaboration independently. Looking at the technological component, it enabled new kinds of activities to supplement traditional vocational classroom and workplace practices. For example, mobile tools were introduced to broaden the physical boundaries of the schools and workplaces; 3D spaces provided safe environments to practice dangerous team-work practices; tangibles provided the possibility to deal with abstract complex tasks by reproducing concrete objects and elaborating data provided by them through augmented reality; and, more generally, technologies enabled the elaboration of group tasks to learn work processes holistically through simulating them in a secure, game-based environment or through documentations (using texts and pictures) that assist collaborative analyzing erroneous practices.

While these technologies are promising, a common framework on how to design both collaboration and collaborative learning is often lacking in the studies. Beyond CSCL, it seems that other frameworks are more central in VET research even when collaborative learning is used to design the studies. This suggests that a more specific framework for CSCL in VET is still lacking. Specifically, the combination of school-based and work-based actors (teachers and supervisors) and actions (intertwining learning activities at both locations) defines VET as a specific research field. We see this field as an interesting opportunity to investigate how collaboration structures in a context, where the interaction among people inhabiting different locations is fundamental for the effective functioning of the system itself.

These results suggest the existence of many opportunities for establishing a specific field of research on CSCL in initial VET. It can benefit from investigating the intersections between vocational practices, learning specific work-related skills (such as motor skills, factual knowledge, procedural knowledge), and general skills (such as social and communication skills). To strengthen and further develop this research field, it requires the development of a theory-based, VET-specific framework informing technology design and its intersection with collaboration and learning processes.

To conclude, we hope that the current review is of use to the community by identifying possible streams of research such as the opportunity for developing a common framework and by fostering future CSCL VET research.

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Newcomer Integration Strategies in Blogger Online Knowledge Building Communities: A Dialog Analysis

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Abstract: Online knowledge building communities (OKBCs) are sustainable over longer periods of time only if they constantly integrate newcomers. Previous research, based on self-reported data, suggest that OKBC members intentionally use strategies such as advertising, positive or negative welcoming, knowledge assessment, mentoring, or consistent newcomer training. Based on dialog analysis of approx. 143,000 comments produced by 2085 participants during one year in twelve blogger OKBCs, this study confirms the use of newcomer integration strategies. Moreover, it refines and structures the analysis instrument, describing three categories of strategies (recruiting activities, practice-oriented interaction, and socializing) with further sub-categories, thus contributing to a deeper understanding of socio-cognitive processes in OKBCs, and potentially to extending Social Knowledge Analytics applications in CSCL.

Introduction

Online knowledge building communities (OKBCs) are already established for more than two decades as environments for collaborative, formal or informal learning environments (e.g., Scardamalia & Bereiter, 2006). They are sustainable over longer periods of time only if they constantly integrate newcomers. Eberle, Stegmann, and Fischer (2014) examined faculty student councils in face-to-face settings, and identified a number of specific strategies, further asserting that the intentional use of newcomer integration strategies generally occurs in communities of practice. So far, such strategies were insufficiently studied in OKBCs.

In this study, newcomer integration strategies were identified in blogger OKBCs by means of dialog analysis. Moreover, the analysis categories proposed and applied by Eberle et al. (2014) were refined and structured. For educational practice, the study suggests a way of connecting informal learning in OKBCs with formal learning, e.g. in higher education (Greenhow & Lewin, 2016). OKBCs with appropriate discussion topics and, additionally, with a more frequent use of newcomer integration strategies can be selected for student inquiries. At the same time, the underlying dialog analysis can be performed automatically (Nistor, Dascălu, & Trăușan-Matu, 2016). For educational research, the study extends the insight in the socio-cognitive processes in OKBCs, provides an instrument of analysis, and potentially supports Social Learning Analytics applications.

Theoretical framework

Relying on a definition provided by Wenger (1998), OKBCs are groups of mutually engaged people communicating online over longer periods of time, and sharing interests, knowledge and activities. Most researchers assume that OKBCs display core-periphery socio-cognitive structures similarly to those described by Lave and Wenger (1991) in communities of practice. These include experts at the center, novices at the periphery, and in between regular, active members who carry out the largest part of the community practice. A knowledge building community lives from the diversity of its members, meaning that there are oldtimers and newcomers, experts and novices, all of which can participate at the center, at the periphery, or in the intermediate socio-cognitive layers, and learn from and with each other. According to Lave and Wenger (1991; also Scardamalia & Bereiter, 2006), learning in such communities is tightly connected with the negotiation of a peripheral vs. central member identity. The ideal learning trajectory begins for newcomers with the novice identity and peripheral participation, and evolves in time towards the expert identity and central participation (Lave & Wenger, 1991). According to Wenger (1998), learning resides in the interplay of participation and reification. Participation supports the construction of experiential knowledge, which is being reified, i.e., transformed to material or immaterial (conceptual) artifacts that, in turn, support participation at a higher level.

Users of communication technologies, from email and newsgroups to social media (including blog platforms; Deng & Yuen, 2011) and virtual reality, build similar communities with similar socio-cognitive structures. However, some researchers (e.g., Zhang, Ackerman, & Adamic, 2007) argue that online communities are mainly help-seeking communities (Karabenick & Puustinen, 2013). Here the members who most intensively seek help play the central role, while experts participate only peripherally. Either way, significant learning seems to take place at the OKBC periphery, which nevertheless corresponds to Lave and Wenger's (1991) view of learning as legitimate peripheral participation. Reification, i.e., artifact production plays the same central role in the process of learning, whereas OKBCs mostly produce immaterial or conceptual artifacts such as collections of frequently asked questions and answers, or blog articles (Deng & Yuen, 2011).

There are always members leaving the community for some reasons, so that the remaining members constantly need to integrate newcomers in order to keep the community alive and sustainable over longer periods of time. Therefore, they intentionally apply newcomer integration strategies, observed and described by Eberle et al. (2014) as follows.

First, these were participation support structures derived from workplace learning research. *Positive welcoming strategies* accompany a newcomers' first contact with the community and aim to foster newcomers' gratitude towards the community and their interest to acquire specific community knowledge. On the other hand, *negative welcoming strategies* are initiations confronting newcomers with their own shortcomings, which aim to show them the need to attain a higher level of knowledge and skills to become full community members. Further, *modeling* is performed by senior community members who show newcomers how to behave according to community norms. *Sponsoring* is done by existing members who bring new members, and take the responsibility for their behavior and participation in the community. *Mentoring* designates a long-term newcomer-oldtimer relationship, in which the oldtimer shares knowledge and experiences, and supports the newcomer deliberately. Oldtimers *encapsulate* newcomers by encouraging them to spend time with and for the community. *Consistent training* aims to support a constant learning process, in line with community norms and values. *Monitoring* and *knowledge assessment* evaluate newcomers' knowledge about, and their behavior in the community practice.

Second, Eberle et al. (2014) added two categories they regarded as classical participation support structures in communities of practice (Lave & Wenger, 1991). Offering *opportunities for peripheral participation* (accepting and inviting to different levels of participation, including passive participation, offering small tasks, working together) opens the entrance of a community and supports the newcomers to participate according to their wishes and aptitudes. Also, *legitimation strategies* include advertising, approaching potential newcomers directly, and welcoming interested newcomers.

Third, the authors observed additional participation support structures. *Recruitment strategies* (job offers, written information, contact) comprise advertising and offering general information about the community in order to attract newcomers. *Accessibility of community knowledge* enables knowledge sharing and participation (listening, asking, job introduction, general introduction, written information), and may complement recruitment strategies.

A critical examination of these categories reveals a clear research gap. Eberle et al. (2014) provide an additive, unstructured category system that includes redundancies between the three categories. Their study is based on subjective data from face-to-face settings. To our knowledge, their studies have not been replicated, yet. In online settings, Nistor (2016) has conducted a questionnaire survey in massively multiplayer online role-playing OKBCs confirming the use of newcomer integration strategies. Furthermore, Nistor et al. (2016) have performed automated dialog analysis in OKBCs, predicting the success of newcomer integration, i.e., whether newcomer inquiries lead to integration in the community discourse. Gaining more in-depth understanding of the newcomer integration process in OKBCs may extend the existing automated dialog analysis methods and tools, thus extending the Social Learning Analytics applications in CSCL.

Purpose and methodology

Addressing the research gap discussed above, this study aimed to identify newcomer integration strategies in blogger OKBCs and their occurrence frequencies. At the same time, difficulties with applying the available analysis categories were recorded, helping to specify them for the OKBC environment, to refine and structure them for the use in further research.

Accordingly, a dialog analysis with both quantitative and qualitative components was conducted. The quantitative part addressed the occurrence frequencies of the newcomer integration strategies, while the qualitative part comprised the specification and refinement of the analysis categories for the OKBC environment, including their structured representation in categories and subcategories. The corpus of analysis was produced in 12 blogs, four in each of the three topic categories: cooking, politics and economy, and science. Here, a total of N = 2085 active participants had made approx. 143,000 comments within one year.

The newcomer integration strategies described by Eberle et al. (2014) were used as analysis categories. Each of six groups of graduate students of Educational Sciences analyzed the dialog from two blogger OKBCs. The groups were composed of 4-5 students who searched and identified expressions of newcomer integration strategies in the OKBC dialog. Whenever the group members coded the material differently, they discussed the dialog and proposed rephrasing the original categories so that they could agree on the coding. Finally, the refined categories were synthesized and grouped according to the logic of the integration process, building categories and subcategories at four levels (Table 1).

Findings

The frequencies of the newcomer integration strategies (Table 1) and the refined category definitions are briefly presented in the following.

Preliminary to newcomer integration, OKBC members carried out *recruitment activities* (33 occurrences in total), posting messages about their communities in other OKBCs, inviting individuals to participate in their OKBCs, offering their contact addresses, or offering jobs. This category was relatively infrequent, as compared with the *practice-oriented interaction* (229 occurrences), which was further divided in three subcategories:

- Within *beginning interaction* (67), newcomers were individually, either explicitly and positively welcomed (28), or negatively welcomed, often by ironical comments questioning newcomer's knowledge (24). Additionally, generic expressions of openness towards newcomers (6), of opportunities for peripheral participation (5), and statements accepting different levels of participation (4) were found.
- Within *short-term interaction* (85), oldtimers often referred newcomers to information reifying community knowledge as written text, such as frequently asked questions (FAQs)(51), or simply answered newcomers' questions (27). In some cases, oldtimers helped newcomers to understand specific aspects of the OKBC practice.
- Within *long-term interaction* (77), oldtimers kept employing integration strategies, however in a more complex way. Detailed activity descriptions (e.g., how to season Asian pickles, or how house and ground prices change when interest rates vary) were coded as modeling an activity within the limits of text-based communication. Thus, roles and activities were frequently modeled, and oldtimers together with newcomers reflected and elaborated on these (33). Similarly, newcomers were consistently trained (11), their participation in the OKBC practice was monitored, and their corresponding knowledge was assessed (8). Beside expert-novice interaction, situations were also found where oldtimers and newcomers collaboratively explained or elaborated on concept meaning, which was regarded as peer interaction (25).

Finally, a few cases of oldtimer-newcomer interaction were found that did not address the OKBC practice. These were forms of *socializing*, such as oldtimers introducing themselves (7), sponsoring newcomers (3), or inviting them to face-to-face activities (1).

Table 1: Structured categories of newcomer integration strategies, and their occurrence frequencies

<table>
<tr><td rowspan="4">Recruitment activities (33)</td><td colspan="3">Advertising (16)</td></tr>
<tr><td colspan="3">Invitations to participation (15)</td></tr>
<tr><td colspan="3">Initiating contact (1)</td></tr>
<tr><td colspan="3">Job offers (1)</td></tr>
<tr><td rowspan="12">Contents/practice oriented interaction (229)</td><td rowspan="5">Interaction begin (67)</td><td colspan="2">Positive welcoming (28)</td></tr>
<tr><td colspan="2">Negative welcoming (24)</td></tr>
<tr><td colspan="2">Expressing generic openness towards newcomers (6)</td></tr>
<tr><td colspan="2">Offering opportunities for peripheral participation (5)</td></tr>
<tr><td colspan="2">Accepting different levels of participation (4)</td></tr>
<tr><td rowspan="3">Short-term interaction (85)</td><td colspan="2">Referring to written information (e.g., FAQ) (51)</td></tr>
<tr><td colspan="2">Answering newcomer questions (27)</td></tr>
<tr><td colspan="2">Offering comprehension support (7)</td></tr>
<tr><td rowspan="4">Long-term interaction (77)</td><td rowspan="3">Expert-novice interaction (52)</td><td>Offering role models, modeling activities, reflecting, elaborating (33)</td></tr>
<tr><td>Consistent training (explaining basic knowledge, explaining expectations) (11)</td></tr>
<tr><td>Monitoring, knowledge assessment (8)</td></tr>
<tr><td colspan="2">Peer interaction, working together (25)</td></tr>
<tr><td rowspan="2">Socializing (11)</td><td colspan="3">Self-introduction (7)</td></tr>
<tr><td colspan="3">Sponsoring (3)</td></tr>
</table>

	Encapsulation, offline social activities (1)

Conclusions

This study examined blogger OKBCs (Deng & Yuen, 2011; Greenhow & Lewin, 2016; Nistor et al., 2016; Scardamalia & Bereiter, 2006), identifying newcomer integration strategies (Eberle et al., 2014) used within the community dialog. The most frequent integration strategies occurred in the context of community practice. The frequency of use was roughly the same at the beginning, in short-term, and in long-term interaction newcomer-oldtimer interaction. However, the specifically used strategies were different in these three categories. At the beginning of the interaction, oldtimers welcomed newcomers in a way meant to stimulate them to reflect about their own capabilities, and to participate in the OKCB at corresponding level. In short-term interaction, oldtimers shared knowledge with newcomers. Long-term interaction added oldtimer contributions to, and responsibility for, newcomers' knowledge construction and identity development from a peripheral towards central participation. This was essentially done as consistent training within expert-novice interaction on the one hand, and as collaboration within peer interaction on the other. Beside practice-oriented interaction, recruiting activities and socializing were also present, although less frequent.

These findings are consistent with previous research in face-to-face communities of practice (Eberle et al., 2014), and in massively multiplayer online role-playing OKBCs (Nistor, 2016). However, unlike previous research that is based on self-reported data from interviews and questionnaire surveys, this study is grounded on dialog analysis data. Therefore, it displays higher internal and ecological validity. Moreover, the study revalidated, refined and structured the dialog analysis instrument, thus potentially contributing to an automated dialog analysis focused on newcomer integration strategies (Nistor et al., 2016).

The presented findings are soon to be complemented by the assessment of inter-rater reliability; larger samples of online OKBC discussions may additionally increase the result validity. Broader dialog analyses should examine learning trajectories in OKBCs, and possibly connect informal learning in OKBCs with formal learning, e.g., in higher education (Greenhow & Lewin, 2016).

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Designing Spaces for Collaboration in Practice-Based Learning

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Abstract: In order to support equity and access in collaborative learning, it is important to understand the nature of collaborative learning itself. One approach is to look at the physical aspects of how students collaborate while engaged in open-ended group-work during Practice-Based Learning (PBL) activities. By analysing how students and teachers move and interact in relation to each other, the space they are in and the objects within it, we can gain a greater understanding of the physical nature of collaborative group-work. This understanding can help us to create a learning environment that intrinsically but unobtrusively supports access by all user profiles who seek to engage with it, thus promoting equity of engagement and participation. Using the example of the design of a Learning Analytics System (LAS) and the educational furniture in which it is implemented, we will show how the physical design of a CSCL implementation can support increased collaboration.

Keywords: Computer Supported Collaborative Learning (CSCL), Learning Analytics, Practice-Based Learning, learning environment, educational furniture, collaboration, equity, access.

Introduction

Recent studies have shown a lack of diversity in the technology sector workforce (NEC, 2015). One of the contributory factors for this is the poor take-up of science, technology, engineering and mathematics (STEM) subjects in secondary level education and technology related courses at third level among some student groups, thereby leading to a resultant skills shortage and under-representation of these groups in the technology sector workforce (EU, 2015). By promoting collaboration in the delivery of education in the relevant subject areas, potential solutions to address this lack of diversity can emerge. Computer Supported Collaborative Learning (CSCL) is a pedagogical approach which can be used during educational activities in many of the STEM subjects relevant to the development of a technology proficient workforce (Do-Lenh et al., 2012). The premise of CSCL is that enhanced learning takes place when students interact and collaborate during the completion of computer supported educational activities (Dillenbourg, 1999). Our approach in this paper, is to pose the question, what is the physical nature of collaboration, movement and interaction during practice-based learning activities? Taking the example of a series of user trials during the research and design of a LAS and a suitable physical embodiment in which to implement it, we seek to demonstrate how a greater understanding of the physical nature of collaboration can help in the design of an educational environment. Through understanding and facilitating increased interaction and collaboration, the authors seek to make participation in CSCL activities more equitable and accessible, which may encourage greater engagement with STEM activities through CSCL by a broad and diverse range of user groups.

Background

The work described in this article has been carried out as part of the PELARS (Practice-based Experiential Learning Analytics Research and Support) project, a three year, European Union funded, research and design project that seeks to create a LAS suitable for implementation in the teaching of practice-based learning activities in three learning contexts, secondary (high school) STEM subjects, third level (university) interaction design and third level engineering education. Given the diverse user profile associated with these three contexts, consideration of equity and accessibility were of paramount importance to the project partners from the outset. The project seeks to understand how students learn while engaged in open-ended Collaborative Problem Solving (CPS) in PBL activities (Cukurova, et al, 2016). Typically, the physical design of CSCL interventions and the environments in which they are implemented is driven from an instrumental and technological viewpoint rather than ergonomic and human factor affordances provided to the proposed user group (Jones et al., 2006). In order to fully support interaction and collaboration, we need to understand and consider the physical design of the collaborative workspace. By designing a learning environment taking into account movement and interaction on a macro (classroom) scale, we seek to encourage collaborations on a meso (group) and micro (individual) scale.

Methodology

The aim of the design of the physical aspects of the PELARS project is to consider as diverse a range of potential users at the outset of the project and define a set of requirements based on these user profiles. Through the translation of these requirements into a design brief which is iteratively prototyped, tested in a series of user trials, evaluated and incrementally improved, an empathetic design process develops which ensures that the end product meets the needs of the user group in an equitable and accessible manner. There are two aspects to the design of the physical elements of the project - the educational furniture in which the LAS technology is embedded and the implementation of that furniture within an educational space. The section below outlines the key human factors for consideration in the design of both aspects. The furniture prototypes were tested in a series of user trials to examine various aspects of the design, two of which are listed below.

Educational furniture (Meso level)

Key human factors relating to the proposed users regarding equity and access to be addressed in the design process were identified in the research phase of the project and are listed below:

1. Physical profile and ability - design to allow usage by a broad range of abilities.
2. Ergonomics – ensure height, reach, sight-lines etc. are suitable for the user group or are adjustable.
3. Skill level – intuitive in use.
4. Maturity – design to account for intentional misuse, safety considerations.
5. Teacher/student interaction - design to enable equitable interactions in terms of dynamics and time.

Trial 1

This trial was constructed to test the factors listed above. The hypothesis of the trial is that students engaged in a PBL task at standing height tables would physically move more than those seated at standard height tables and that these movements would give rise to more interactions with their peers. Six 18mm thick wooden table tops were produced for this trial, two circular tables (1,000mm diameter), two hexagonal tables (1,000mm width) and two square tables (900mm width). One table top of each shape was mounted at 770mm (sitting height) and at 1,020mm (standing height), creating six test scenarios. Groups of three students were randomly asked to carry out a task at each of the six tables while being observed and video recorded. The task was to assemble the components of a programmable kit and code it using a laptop to control the movement of a laser pointer to hit a target. The task lasted 57 mins 45 seconds. The results of this trial are listed in the results section.

Furniture implementation (Macro level)

During the analysis of the data from Trial 1, it was noted that examining the usage of the furniture at the "meso" or group scale during an activity does not necessarily give a full picture of what is happening in the classroom. Movements of students away from their designated table (and where and why they moved), of the teacher/ facilitator through the class and interactions away from the table were not captured, creating potential gaps in the LAS data set. In order to evaluate the design intent of the furniture, i.e. that it encouraged more collaboration and interaction between groups, a method of capturing the all these movements and interactions (using multiple video cameras and time-lapse photography) was devised and implemented for the next user trial.

Trial 2

The purpose of this trial (along with testing the LAS) was to record the movement and interactions of students engaged in a practice-based learning task at specially designed standing tables with circular table tops to allow comparison with those of their peers seated at standard height rectangular tables. It further sought to track the movements and interactions of the teachers / facilitators during the activity. In the trial sixteen secondary school students were divided into five groups. Two groups of three students were randomly selected to work on specially designed standing height round workstations while the remaining three groups (two groups of three and one of four students) were seated at standard desk height rectangular tables. Following the briefing, the activity lasted 92 minutes and involved the construction of an interactive toy using an Arduino programmable kit.

The evaluation methodology of both of the trials below consisted of a combination of quantitative and qualitative data gathered from multi-modal data sources ranging from heuristics, interviews, video and sound recordings, still and time-lapse photographs, data provided by the LAS system and student generated feedback via "sentiment" buttons and an on-line mobile application (Healion & Russell, 2016). All the above data was analysed, with the results prioritised and used to inform the next iteration of the relevant design element. In this paper, we focus on the analysis of student movements and the frequency of their interactions.

Results

Trial 1 - Test of table height and shape

Our results show that high tables at which students stand seemed to encourage greater physical movement of the students during a PBL activity. During the activity, there was a total of 88 separate moves away from the three high tables (Average 29.3) compared to total of 14 from the low seated tables (Average 4.6). This greater ease of movement seemed to encourage students to initiate more frequent interactions with their peers in other groups. There was a total of 19 separate peer interactions initiated by students from the three high tables (Average 6.3) compared to total of 11 from the low seated tables (Average 3.6) – although eight of these 11 were initiated by one outlying student. Groups at the high tables were much more likely to change the group configuration during the activity and to reform it according to their needs and changing roles within the activity giving a total of 45 group configuration changes by students at the three high tables (Average 15) compared to a total of one from the low seated tables (Average 0.3). Of the groups at the high tables, the round table seemed to encourage the most configuration changes (23), followed by the hexagonal table (17) and the square table (5). From observations, it was noted that the facets or sides on the hexagonal and square table seems to act as locators for students to denote positions that they were more likely to return to – the more defined the facet, as in the square table, the greater the likelihood that the students return to their previous position. The high tables seemed to encourage the students to work closer together physically. Typically the standing students stood shoulder to shoulder as close as personal space would allow to view a laptop, discuss the task or during the component building in angles between 90 to 180 degrees, whereas students at the low tables sat at 90 degrees or faced each other.

Trial 2 - Analysis of movement and interaction

Time spent by each individual student at their appointed table ranged from 100% of the activity (Students 11, 15 & 16 – low tables) to 72.3% (Student 5 – high table) with an average of 91.48% (Average at high tables 88.7%, 93.2% at low tables). The number of student location changes ranged from an outlying 46 (Student 9 – low table) to 0 (jointly Students 11, 15 – low table) with an average of 14.1 changes (Average at high tables 16.7, 12.7 at low tables). The number of interactions (per student) with other student groups ranged from 0 (Student 15) to 8 (Student 14 – low table) with an average of 3.25 interactions. (Average at high tables 3.5, 3.1 at low tables).

In general, increased physical movement and location changes around the classroom correlated with increased interaction with other groups, but not always as evidenced by Student 9, who had the highest number of location changes (46), but the joint lowest number of interactions with other groups (1). Assignation of roles within the group also has an effect on duration of time present at the workstation. The selected diagrams below were chosen from the ten diagrams generated to show the most amount of student movement (Fig. 1(a) Student 5) and movements of the main facilitator (Fig. 1(b) Facilitator 1). Each line represents a return movement for the subject involved unless an onward movement is indicated.

(a) (b)

Figure 1. Spaghetti diagram showing the movements of Student 5 (a) and Facilitator 1 (b) during the activity

The results detailed above, combined with heuristic evaluation and anthropometric considerations have informed the design of the current iteration of the PELARS furniture which is composed of two distinct units, designed to work together as part of a flexible classroom layout. The first, is a table that provides a circular surface for collaborative group based learning. The height and surface form of the table was developed in response to trials which indicated that a raised surface and circular form promote increased collaboration and movement. The scale of the surface ensures physical accessibility to project work (Healion & Russell, 2015). The raised surface height may promote a greater sense of equality within the classroom as student and teacher are both working at the same level and posture. The second, is a frame that integrates the LAS technology whilst also supporting a digital display, two whiteboards and an additional work surface. The frame is developed to support equitable visibility of, and access to, the graphical user interface. It can be positioned against the table at any point and provides good line of sight for all students at the table. Our trials have shown that existing furniture can result in individuals monopolising delivery of certain tasks, whether programming based or relating to physical assembly. The combined shape of the table and the positioning of the monitor support shared task completion and learning across the group. The design and placement of these furniture elements within the learning environment has been shown from the trial results above to have a positive effect on the number of movements and interactions between the student groups and seeks to facilitate ease of access through the ergonomic and anthropometric considerations. The resultant increase in mobility and interactions are key to enable effective collaboration among and within groups in dynamic PBL environments.

Conclusion and discussion

The analysis of student and teacher movement through the classroom while engaged in CPS in PBL activities has meaningful implications for the design and development of CSCL implementations. By understanding the nature of collaboration and interaction between peers and student to teacher at the macro level while engaged in PBL activities, more effective, equitable and accessible educational and learning environments can be created. This approach has shown to be effective in the design of the current iteration of the PELARS furniture, the form of which has been directed by a deeper understanding of collaborative learning achieved through the user trials. The current design has been shown to promote movement and interaction within the learning environment, which then can lead to more effective collaboration between groups as well as amongst group members. Improved learning environments that promote equity and access can assist in the engagement of a diverse range of students with STEM subjects and activities with the potential to generate a greater interest and take-up of these subjects at third level, creating a more diverse workforce in the technology sector

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Reflections on Pair E-Crafting: High School Students' Approaches to Collaboration in Electronic Textiles Projects

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Abstract. Pair programming is one of the most popular and successful collaborative learning activities in computer science education wherein students organized in pairs alternate between writing and guiding coding on the screen. In this paper, we examine a complementary approach by taking pair programming into a tangible space where pairs coded lights and sensors of an Arduino-based microcontroller, designed programmable and functional circuits, and sewed an electronic textile. We analyzed the reflections of 23 students, who worked in pairs over a series of fifteen 90-minute workshop sessions, about their experiences collaborating and communicating across the different domains of e-textiles creation (e.g., design, circuitry, coding, and crafting). Student perceptions highlighted potential causes of these interactions across these multiple domains, which are distinct from pair programming activities. In the discussion, we address how these perceptions inform the design and development of more equitable pair e-crafting arrangements.

Introduction

The recent call for computer science education for all (Smith, 2016) stresses the need for better understanding the design of different contexts, tools, and communities for learning and teaching computing. One of the most promising arrangements in learning coding has been pair programming (McDowell, Werner, Bullock, & Fernald, 2003), wherein tasks and communication are prescribed within interactions between two individuals. While past research of pair programming has focused on screen collaborations, the potential benefits of these collaborations for more tangible computing activities (such as robotics or electronic textiles) is apparent, especially in terms of opportunities for peer support and reduction of material costs. For this reason, we focus on a new pair arrangement of work within these multimodal computational contexts that we call "pair e-crafting." Building on pair programming, pair e-crafting emphasizes partnership between students in building an electronic textile (e-textiles; Buechley, Peppler, Eisenberg, & Kafai, 2013), where students must negotiate the physical realm of electrical circuits sewn together with conductive thread, along with the digital realm of computer code that controls these circuits. In order to accommodate the multiplicity of these activities, individual tasks and interactions are not as prescribed as with pair programming; however, this partnership still requires coordination and team communication for success.

In this paper, we contribute an understanding of how students negotiate and coordinate the demands posed by multimodal computational work within a paired partnership. We draw on perceptual data to gain perspective on how student pairs conceptualized their engagement with each other, looking particularly at distribution of tasks and communication contexts. We interviewed a class of 23 students, who worked in pairs on e-textile designs, to address the following questions: 1) How did students conceptualize collaboration and distribution of tasks across the different domains of e-textiles creation? 2) How did they communicate within these collaborations? In emphasizing students' perception of these issues, our findings provide a basis on which to inform future implementation of collaborative, multimodal programming activities.

Background

Within the literature on novice programming, most studies have focused on student's individual performance in how they come to understand key programming concepts and practices (Soloway & Ehrlich, 1984). While some early studies found that students were not able to learn productively in small teams when compared to students engaged in solo programming (e.g., Webb, Ender & Lewis, 1986), other studies found that teams with experienced students design were more capable of providing equitable access to computer work for inexperienced members, calling this *peer pedagogy* (e.g., Ching & Kafai, 2008). The design of pair programming has addressed these benefits and challenges by more explicitly structuring the collaborative interactions between learners (McDowell et al., 2003; Denner, Werner, Ortiz & Campe, 2014). Equitable participation within collaborative teams becomes even more of an issue in multimodal computational activities like e-textiles and robotics, where projects require coordination across screen-based and physical domains. From research on robotics, we know that collaborative interactions can be mitigated by uncertainty, gender, and agency (e.g. Sullivan, Keith, & Wilson, 2015). Similarly, studies on collaborative e-textiles arrangements suggest that equitable participation in the different required domains (design, crafting, circuitry, and coding) is difficult to accomplish depending on individuals' prior and perceived experience within these areas (Buchholz, Shively, Peppler & Wohlwend, 2014; Kafai, Searle, & Fields, 2014), something that can be exasperated within team collaboration of three or more (Litts, Kafai, & Dieckmeyer, 2015). In our current study of pair e-crafting, we explore smaller teams of two students emulating pair programming. From related work observing social interactions in pair e-crafting (Lui, Litts, Widman, Walker, & Kafai, 2016), we know that coordination of tasks and communication are key factors in determining pair productivity and success. For that reason, we primarily focus on students' perceptions of their pair experience, examining how students' understandings of tasks and communication framed their interactions, in order to help shed light on how to best address potential challenges and opportunities for collaborative learning.

Methods

Participants and workshop design

We conducted this study with 23 high school juniors (4 boys, 19 girls, 16-17 years old), within a STEM elective course at a charter school in a Northeastern metropolitan city. Prior to the study, the teacher put students in pairs aiming to balance personality traits and existing friendships. Over fifteen 90-minute class periods, pairs were guided through the creation of a collaborative e-textiles sign that spelled out the name of the school and was publicly displayed. Each pair was assigned a pre-designed canvas print of a single letter created by an art student in the same school, and responsible for making these pieces interactive by adding components such as LilyPad Arduinos, switches, sensors, and LEDs and generating codes four different light patterns. The teacher together with graduate assistants prepared and guided classroom sessions. After an introduction to e-textiles, the class was divided into two major phases. During phase one (roughly 5 days), pairs focused on project planning, including its *design*, when students made decisions about the aesthetics and functionality of their project, and its *circuitry*, when students mapped out the appropriate connections between the electrical components. During phase two (roughly 10 days), pairs focused on project construction, including *coding* the behaviors of the project using text-based Arduino code, and *crafting* by sewing the project together.

Data collection and analysis

At the end of the workshop, we conducted semi-structured interviews (averaging 15 minutes) with all 23 students individually, which we video recorded and transcribed. We asked about their processes working on their designs, experiences working with a partner, experience working on a design project, and their feedback on the structure of the course. Two authors coded all of the interviews in several iterative cycles following previously published coding methods (Saldaña, 2009). In the first cycle, we began with provisional codes, drawing from prior research on pair programming and e-textiles. We focused on two key features of pair programming collaboration (tasks and communication) and four domains of e-textiles (design, circuitry, coding, and crafting). We then employed several rounds to develop subcodes and themes. These are further elaborated in the findings. Across all interviews there were 215 coded excerpts in total.

Findings

In our findings, we provide students' perceptions about task distribution and communication, which shaped their peer interactions and design process.

Distributing tasks across e-textiles domains

Pairs described different approaches toward distributing tasks around domain-types. Of the 163 task-related excerpts (out of 215 total), 69 were coded as design, 39 as circuitry, 83 as coding, and 85 as crafting. The relative proportion of these domains corresponded to our observations of the class: students spent much more time with the coding and crafting of their projects than circuitry and design. These codes were not mutually exclusive, as our previous research on collaborative e-textiles revealed inherent interdisciplinarity of tasks (Litts et al., 2015; Lui et al., 2016). We also looked at whether, and how, students perceived the different e-textiles domains as supporting more shared or individual work approaches, something we coded as mutually exclusive. In terms of *shared* tasks, 80% and 79% (55 of 69 design codes, and 31 of 39 circuitry codes) of students' reporting on *design* and *circuitry* respectively, expressed these as shared rather than individual. As described by students, this resulted from the inherently interconnected nature of design and circuitry—that is, it is impossible to determine the visual layout of an e-textiles project without considering the necessary electrical connections, and vice versa. In terms of *individual* tasks, 54% and 59% (or 45 of 83 coding codes and 50 of 85 crafting codes) of students' reporting on coding and crafting respectively, identified work in these domains as individual rather than shared. Mostly, this was because crafting and coding were distinct tasks only one person could perform at a time and required different kinds of expertise. As a result, all pairs except one adopted more individual approaches towards these tasks. Thus, while students generally saw circuitry and design as more interrelated domains and thus more easily shared, they saw coding and crafting as domains that were inherently distinct, requiring separate realms of knowledge and skills.

Communicating within a pair e-crafting arrangement

Students reported three primary contexts in which they communicated about their project: decision-making, peer pedagogy, and absences. *Decision-making* (57 of 215 total excerpts) captures communication related to key project-related decisions pairs made throughout their design process. Most decision-making 54% (or 31 of 57) was related to the overall design of the project whereas 42% (25 of 57) were related to crafting, 40% (23 of 57) related to coding, and 23% (13 of 57) related to circuitry. This distribution can partially be explained by the prominence of design in the project in general. As described by students, project decisions involving design (i.e., the aesthetic placement of components, the usability of the project) always trickled down to the other domains of work. *Peer pedagogy* (33 of 215 total excerpts) captures instances where students reported teaching or learning from their partner, which most often occurred in the domain contexts of coding (21 times of 47 task occurrences) and crafting (20 times of 47 task occurrences) compared to circuitry (3 of 47 task occurrences) or design (3 of 47 task occurrences). Many students divided their labor within coding and crafting domains according to their relative comfort and expertise; however, when instructors asked students to switch roles, students described explaining their tasks to their partners as well as tips for how to be successful in these arenas. Students also reported peer pedagogy with regard to troubleshooting their project, because it required diagnosing whether the issue was due to circuitry, crafting, or code. Finally, a few students also mentioned *absences* (13 of 215 total excerpts) as a key context of communication. Dealing with absences presents a real-life challenge of doing heavy design work in teams over extended time periods. Almost all the pairs within the workshop dealt with at least one absence over the course of project, while a few experienced excessive partner absences (up to 8 over 15 days). Some of these students described overcoming this obstacle through explicit communication strategies, such as individual project updates outside of class or FaceTiming in class. One pair, though, did not explicitly address these issues and instead opted to work independently, which eventually led to feelings of frustration and difficulties completing the project on time.

Discussion

Our goal in this study was to better understand pair learning arrangements for high school students in making e-textiles designs in order to inform the design of future collaborative learning arrangements within computational contexts. In this section, we share what we learned from student reflections about equitable distribution of work.

Tensions of siloing work in pair e-crafting

Our findings reveal how collaboration can occur within the context of computational projects that involve both physical and digital construction. Though students had more potential avenues for individual engagement and interests (design, circuitry, coding, crafting), we also illustrated how this can work against more equitable learning arrangements through the creation of siloed work, roles, and identification. Given the multimodal complexities involved in e-textiles, it makes sense that students felt more at ease sticking with and developing a sense of expertise within a single domain. Here students emulated models of distributed labor that can be seen within many professional technological contexts, where teams are often comprised of different people with different expertise, knowledge, or skills. However, in educational contexts where we want students to gain equal access to different forms of knowledge and understanding, these distributed models of collaboration can result in ongoing knowledge inequities, wherein students who are already comfortable with certain topics (e.g., coding, circuitry) remain ahead and others remain behind. This inequity is further exasperated by the value judgments that are often affiliated with the different domains of e-textiles, which are usually viewed within the false binary of 'low-tech' or 'high-tech' (i.e., crafting and coding, respectively). Thus, in planning for pair work within multimodal contexts, it is important balance the benefits of supporting students' existing interests and experiences with the potential dangers of allowing students to self-segregate into these roles and identification.

Designing for fluency across domains

One major advantage of multimodal computational contexts for learning is that it can provide multiple avenues for individual engagement and learning (Kafai, Searle, & Fields, 2014). Within a classroom, however, there is a need to push people beyond their comfort zones toward new arenas. From this perspective, how can we promote the ethos of self-motivation and personal expression, even while getting students to do things that they might not otherwise pursue on their own? A possible solution is to leverage moments of decision-making and troubleshooting that naturally arise within these tangible computational contexts, as these interdisciplinary problem spaces require strategic sharing and negotiation of expertise between partners. Educators using pair e-crafting arrangements might consider capitalizing these moments by providing scaffolds to help students develop their inter-domain thinking and efforts. Another solution involves a more structured arrangement of sharing tasks that are more individual in nature. Borrowing from the pair-programming model (McDowell et al., 2003), this was something we implemented on the fly within the workshop when we asked students to switch roles. Not only was this a key trigger for peer pedagogy during which pairs taught each other their respective tasks, but also this process forced students to become more engaged with a new domain. In future designs, we plan to embed more purposeful task-switching throughout the design process to explore how it impacts equity in pair e-crafting. While this solution does not address all the challenges that student faced when working in collaborative maker arrangements, it is a foundation upon which more equitable work within making can occur.

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Embracing Learners With Visual Impairments in CSCL

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Abstract: This autoethnographic study aims to shed light on the collaborative experience of a learner with a visual impairment in a blended CSCL environment. Through the analysis of personal reflections, this qualitative study captures some emergent themes and challenges in both the face-to-face and virtual environments with the intent to improve diversity, accessibility, and equity in CSCL.

Keywords: CSCL, visual impairments, accessibility, inclusive design

Marginalized attention to learners with visual impairments in CSCL

Much scholarly work has described the characteristics of CSCL relative to traditional learning and examined its implementation, such as the importance of learning with peers, active participation in a community of learners, and access to enhanced collective thinking processes with the aid of technology (see, Kreijns, Kirschner, & Jochems, 2003; Stahl, 2013). With all of the emphasis CSCL places on collective learning and community, far too little attention has been paid to how such CSCL can be experienced by learners with disabilities. With the support of legislation that advocates equal access to general education for individuals with disabilities (e.g., Section 504 of the Rehabilitation Act 1973; IDEA 1975; and ADA 1990), it has been increasingly more imperative to address the needs of the growing number of learners with disabilities, who traditionally have had limited access to general education, in both K-12 and higher education (Rao, 2004). According to the U.S. National Center for Education Statistics, 95 percent of students with disabilities (ages 6 to 21) were served in secondary regular schools in 2012, and 11 percent of undergraduates reported having disabilities in 2011 (Snyder, de Brey, & Dillow, 2016). This implies that the general education system, where CSCL is increasingly prevalent, now embraces its responsibility to address students with disabilities in its discourse.

Although the historical emergence of CSCL in the early 1990s is indebted to computer-aided composition programs for learners with disabilities to some extent (see Stahl, Koschmann, & Suthers, 2006), recent literature reveals that a relatively small body of work has touched upon this imperative relationship between CSCL and disabilities with limited focus on cognitive disabilities (see Lingnau & Bientzle, 2009). However, in a CSCL-dominant ecology where vision is largely required, learners with visual impairments (hereafter, LVIs) have been faced with inaccessible instructional technologies, such as inappropriate graphic labels, ill-structured e-learning content for assistive technologies, and software/hardware interfaces designed without accessibility in mind (Babu, Singh, & Ganesh, 2010; Fichten, Asuncion, Barile, Ferraro, & Wolforth, 2009; Taylor, 2016).

While there have been some published accessibility guidelines which can significantly lower the barriers previously mentioned (e.g., WCAG 2.0, 2008; VPAT, 2016) and some universal design principles for learning (see Persson, Åhman, Yngling, & Gulliksen, 2015; Rose, 2000; Scott, Mcguire, & Shaw, 2003), LVIs still have to "encounter a recurrent set of problems with commonly used instructional technology" in CSCL environments (Taylor, 2016, p. 123). According to the 2011 U.S. National Center for Education Statistics report, "Limited staff resources to provide faculty and staff with training on accessibility issues" has been identified as the major barrier (by up to 52 percent of respondents) hindering the implementation of Universal Design in both 2-year and 4-year post-secondary institutions (Raue & Lewis, 2011). This tendency highlights that the lack of awareness of accessibility among faculty, staff, and instructional designers is the primary factor causing digital barriers for LVIs (Taylor, 2016) rather than technical or financial problems (Babu et al., 2010; Fichten et al., 2009; Lazar, Allen, Kleinman, & Malarkey, 2007). Understanding the CSCL experience of LVIs, therefore, is instrumental to define which challenges LVIs would face, and how to address those issues to prevent them from being excluded. This paper is intended to respond to the paucity of studies on the learning experiences of LVIs in CSCL environments.

Methods

Design and participants

This study follows an autoethnographic research method, which gives the authors an opportunity to expand the understanding of a social phenomenon by capturing personal experiences through the duality of their roles -

participants and researchers (Wall, 2006). All three participants are graduate students at a university in the northeast of the United States. Only one of the participants is blind, and is experienced with assistive technology and web programming; and not all sighted participants are familiar with the LVI's needs.

Procedures

The study took place over a four-week period in an introductory graduate course on CSCL that also adopted a blended CSCL framework. The course implemented a virtual text-based discussion tool, known as CREATE (Borge & Shimoda, under review). This prototype is developed to improve collaborative learning skills. The first virtual meeting on CREATE was considered a pilot designed to encourage participants to use and get familiar with the tool; while the second was structured to discuss questions that were posed by the instructor and related to the course content. The participants attended two face-to-face classes that were designed differently, requiring activities that adopted visual representations. Participants were asked to write self-reflections after each (face-to-face and virtual) meeting. Each participant wrote two reflections during face-to-face meetings and one through CREATE, giving a total of nine reflections. Two phases of data analysis were done, the first was individual and the group did the second collectively. In phase one, each participant reviewed all nine reflections and summarized each individually, highlighting the main themes and listing statements that focused on either emotional or technical challenges. In phase two, participants met twice to discuss the emergent themes, and reached a collective consensus about the three most significant ones. The analysis of the written reflections followed an iterative process, with a focus on common problems that interfered with the main collaborative task on both the group and individual level. In order to structure the analysis, common technical and emotional problems, such as isolation and frustration, which could face the LVI, were outlined using previous accessibility-related literature (Babu et al., 2010; Fichten et al., 2009; Lazar et al., 2007; Taylor, 2016).

Emergent themes

Challenges impeding the LVI

The distinct challenge the LVI encountered on the CREATE system resulted from the lack of web accessibility and limited channels of communication. He used assistive technologies—a screen reader in conjunction with a refreshable braille display—to access and interact with the online system. In the course of the virtual activities, he recurrently struggled with a few technical issues, such as screen reader crashes and conflicts with web browsers, inappropriate forms, graphic labels, and missing HTML semantic tags. The student reported that more than 5 additional hours were spent on testing the CREATE system, and familiarizing himself with some of its inaccessible elements before participating in the session. It was found that the student's responsive participation in the text-based discourse was hindered by the absence of the Accessible Rich Internet Application (WAI-ARIA 1.1, 2016) technique, which caused the most frustration and delay in the online group discussion. CREATE only offered one channel of communication, text-based discourse. So, combined with the accessibility issues, activities often led to misunderstandings between the sighted and the LVI. Seo (the first author) mentioned, "I wanted to talk more and add some more, but had to go with the flow due to the time and slow technology constraints. And, I often missed context. I said to myself, I wish we could have voice chat instead. Then, I would be more responsive and active" (Seo, Week 4 Reflection, September 18, 2016). The paucity of multimodality in CREATE made it expression of frustrations the LVI faced more difficult for the team to recognize.

In the face-to-face environment, on the other hand, the technical problems were significantly minimized because the sighted were able to identify visual and verbal cues that reflected the LVI's moods and reactions. The fact that the LVI could verbally communicate with others in real time, without having to overcome the inaccessible chat entry, largely affected his preference for face-to-face interaction. Although computer-based collaboration was also required in some activities, he was given the flexibility to employ a more accessible combination of tools to his favor: "I hooked up my braille display to my laptop and passed to Mona [the second author], and had her type down what the professor was explaining on the screen in Microsoft word so that I could read them in braille through the connected braille display device--it was successful!" (Seo, Week 6 Reflection, September 29, 2016).

The LVI repeatedly faced difficulties each time the class employed visual-based collaborations, such as creating and sharing diagrams, watching videos, playing with flashcards, etc. In contrast to the online environment, the presence of his sighted teammates, the instructor, and other classmates in the classroom helped him address challenges immediately. Verbal descriptions for videos, and tactile graphics for visual representations were the main alternatives. He preferred tactile materials to verbal descriptions for the complex diagrams since it gave him a chance to decode the meanings by himself, rather than having someone else selectively describing it. The Swell Form heating machine (a heat processor) and swell touch paper (a chemical paper that allows dark and black lines to swell when inserted in the machine) were provided by the university. Using this technology permitted his class to easily produce the needed tactile graphics within a few seconds during the activities. In sum, the analysis shows that the face-to-face CSCL environment is more likely to embrace students with blindness, relative to an inaccessible virtual space, by addressing and transforming the unique challenges of the LVI into a chance for group support and collaboration.

Dissonant experiences

When looking at the reflections of all participants, it is clear that they faced similar challenges at the start of the course. However, when comparing the reflections across time, difficulties faded for the sighted, while remaining prominent for the LVI. In the face-to-face environment, inaccessibility issues persisted throughout. For example, one of the activities required the use of flashcards and some physical movement around the classroom to allow more interaction with other groups. The sighted learners confronted some setbacks in the beginning of the activity that they overcame by watching the visual demonstration of their peers. In contrast, the LVI needed more explanation from the members of his team, and others. Team members acknowledged such struggles and negotiated strategies that would allow them to work together cohesively and ensured equal participation opportunities in all activities. Such social strategies were the first step that the participants took before starting tasks and were constantly revisited by them. Through this form of social negotiation, the team was able to address inaccessibility problems as they occurred in the face-to-face context. Thus though the issues never disappeared the team got better at problem solving and creating more equitable access. Overtime the instructor and the rest of the class also became more aware of potential process problems for the LVI.

Given the distributed nature of the online activities, inaccessibility issues compounded the difficulty of online activities for the LVI. As such, activities that became easier overtime for sighted members remained equally difficult for the LVI. For instance, in the virtual environment and with the use of a new system such as CREATE, all participants struggled at first when completing the discussion activities because the activities were quite different from traditional instructional practices and it was a prototype system. Nonetheless, with practice, the activities became easier for the sighted participants. The LVI experienced constant frustration due to the lack of accessibility combined with the team's inability to collaboratively mitigate problems in real-time settings. Impediments to collaboration were caused by the team's inability to "see" what was going on for the LVI and work together to solve problems.

Team performance

It is essential to highlight the strong relation between the challenges that individuals encounter and their impact on the dynamic of the team's collaboration. What hindered the individual became a problem of the group. Accessibility issues caused delays for the LVI that not only influenced the LVI's performance, but also deviated the focus of the group. After testing out the CREATE environment, all participants expected delays and showed willingness to support each other by providing explanations and ensuring group cohesion. Nonetheless, they could not predict the extent of the challenges during the CREATE discussion sessions until the LVI identified them in a post to the team. Hence, in several incidents, sighted participants did not notice that their peer was left behind during discourse and the group was faced by a communication disconnect. Consequently, sighted members often spent time filling in the gaps and supporting their peer. Given time constraints and accessibility issues, discussion quality often suffered.

Discussion and conclusion

Through the personal reflections of the learners with and without visual impairments, we were able to explore some of the struggles that could face learners with visual impairments in an inclusive and blended CSCL environment. While web accessibility issues can be addressed quickly with a limited amount of technical skill (Lazar et al., 2007) by simply adding some required HTML attributes, the problems it causes are far reaching. Recognizing the challenges faced by the LVI, the designers of the CREATE system have since partnered with the participants as a means of documenting all of the accessibility issues and addressing them as part of the second iteration of the system. Many of the problems faced by the LVI in this context would likely be common problems for any LVI in a CSCL setting.

Within the small group, team members agreed on creating their set of rules such as prioritizing their tasks in order to meet the time constraints and having a checkpoint system to ensure that no one was left behind. As a result, a positive atmosphere allowed learners to feel safe and included, which made tackling difficulties faced by the LVI a community problem instead of an individual struggle. It is imperative to highlight that the inaccessible design was the cause of many setbacks, not the technical abilities of the learner with visual impairment. This study calls for the training of those in charge of designing and instructing inclusive courses with a Universal Design strategy in mind, but also emphasizes the importance of cultivating an inclusive community. Future research is necessary to delve deeper into the design of activities and tools and how they could affect the social and cognitive performance of learners with disabilities.

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Appropriating a Climate Science Discourse About Uncertainty in Online Lessons

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Abstract: In an online lesson on climate change, pairs of students make claims in the context of uncertainties, using graphs from authentic scientific publications designed originally for public use. As students grapple with describing and delimiting sources of uncertainty discerned from these rather sophisticated graphs, they migrate from attributing uncertainty to themselves to climate-related phenomena. The dialogue between students appears to be instrumental in the strengthening of uncertainty-based claims and explanations.

Discourse about uncertainty

Some of the earliest studies on human experience with uncertainty noted the distinction between internal attributions of uncertainty and external ones (Kahneman & Tversky, 1982). To attribute uncertainty internally to the competence of the self forecloses personal agency to resolve or delimit uncertainties arising from natural phenomena. To attribute uncertainty externally suggests a disposition to make sense of the indeterminacy of events in the world. Science curricula have traditionally downplayed or ignored the essential uncertainty of scientific practice, discouraging those students otherwise disposed to look externally to not bother trying. This inaccurate depiction of science deprives students of agency to formulate and explain claims based on limited and fallible evidence and thereby diminishes incentives to learn science (Lemke, 1990). Content understanding is enhanced with attention to the scientific practices of constructing and critiquing claims (Ford, 2008). For this reason, scientific practices have become a central feature of the Next Generation Science Standards (NGSS Lead States, 2013). The online lessons described here on the topic of climate science are part of a suite of lessons where public concerns intersect with controversies within specific fields of science. Climate change is a collective problem complicated by, and perhaps even limited by, citizens' abilities to participate in productive conversation about it (Corner, 2012). These lessons provide scaffolded instruction around scientific graphical representations as well as user-friendly simulations so as to facilitate explanations and conversation. Students make claims based on evidence while also reflecting specifically on how certain they are and to which factors they attribute any uncertainty.

Analyzing screen captures

The students described here participated in a series of online tasks on climate science in a public high school in the northeast of the United States. We recorded their work via computer screen capture, a process that also captured their talk. This paper limits itself to two episodes, as the analysis is ongoing and results are preliminary. The first episode involves a lesson on solar irradiance and the second involves future trends in temperature. In our analysis we transcribe student talk and then search for themes, using methods of interaction analysis (Jordan & Henderson, 1995). Our guiding concern is to determine interactional factors that contribute to the written responses that students provide in these online tasks. Each task sits on a single webpage along which students can scroll and into which they submit a series of responses to prompts. Due to constraints in our study at the time, our data do not include video of the students themselves, only their shared screen. Though this is not ideal, it is still feasible to inspect their interaction via their speech and, at times, their cursor movements.

Appropriating an uncertainty-infused discourse

These lessons discursively position students as competent agents capable of making claims. They orient students to features of authentic graphical representations by providing some contextual information. This is necessary because interpretation goes beyond merely taking up presented evidence. Interpretation is predicated on ways of seeing and making things see-able distinctive to a given discipline (e.g., "highlighting", Goodwin, 1994). That is, people have to be taught to see. So, the extent to which students can draw evidence from data depends crucially on how the data are framed for them. Explicitly addressing uncertainty as part of scientific activity raises questions for students as to how to construe uncertainty in relation to themselves. Typical curricular materials rarely elevate or highlight uncertainty as a salient and productive aspect of scientific practice. It is perhaps counterintuitive to dwell on uncertainty when cultivating the making of claims. But concerted reflection on the tentative and provisional nature of scientific claims should foster greater confidence in them, not less (Latour, 2004). This is because the means of creating an argument conveys essential information about its strength and durability. The students working on these tasks tend to engage in considerable uncertainty-related talk as they prepare written responses to uncertainty-enriched argumentation prompts. In doing so they "appropriate" (Levrini, Fantini, Tasquier, Pecori, & Levin, 2015) climate science discourse in order to deal with what for them are novel forms of uncertainty. To appropriate a discourse is a matter in part of identifying oneself as a legitimate practitioner and of having the resources available to begin to participate successfully.

Uncertainties in the solar irradiance task: General imitation versus waviness

In the Solar Activity Task (see Figure 1), students are told they will make arguments based on evidence. They are first prompted to make claims about whether, "Based on the graph, is Earth's temperature dependent on the level of solar activity?" Since this is an original graph from a scientific publication, let us first note the rich senses of uncertainty embedded in it that the general public would encounter. Both the following year's temperature and solar activity are highly uncertain based on what we know about the present one, as indicated by the light-colored, erratically-varying lines. This uncertainty in yearly fluctuations is managed somewhat by means of a darker, relatively smooth lines described as the "11 yr average" for each quantity. Based on our knowledge of the 11-year average for a given year, the 11-year average for the next year is comparatively less uncertain. By taming somewhat the fluctuations in quantities in this way, it becomes more feasible to see beyond year-to-year variations so as to inspect trends over decades. The original authors' intent was to show to the general public that solar activity and temperature run parallel (until about 1960) and then diverge.

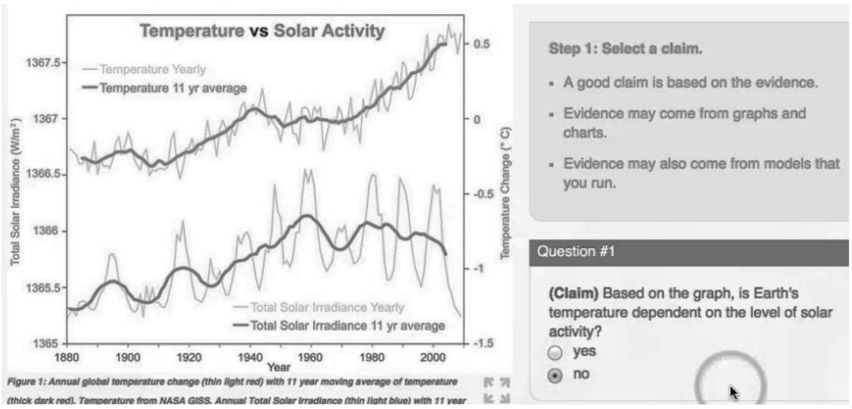


Figure 1. Cropped Portion of Screenshot of the Solar Activity Webpage for Annie and Betty.

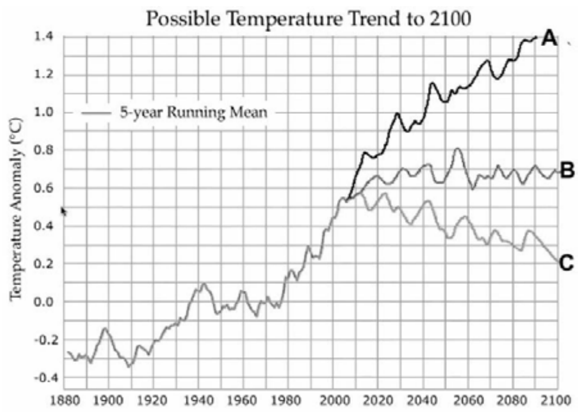
The audience for this lesson consists of students rather than the general public. In providing a limited synopsis, the webpage for the lesson explains that, "The graph shows Earth's air temperature and solar activity (irradiance) from 1880 to 2009. Solar activity includes sunspots, solar flares, and other solar weather events. The light-colored lines show the yearly measurements, and the darker lines show the average of 11 years of temperature or solar irradiance data. Earth's temperature is affected by many different factors" (cropped out of Figure 1). By giving students the task of making claims with only limited additional information, the task frames the interpretation of this authentic scientific graph as an activity students are capable of doing as well as any other public person. And they can presumably do so without having to attend to the layered meanings of some terms (e.g., the unit, W/m^2) or deeper reflections on the data processing of measurements (e.g., How the earth comes to have a singular temperature for a given year).

Table 1 illustrates the kind of conversation that can transpire with a task of this kind. The left column includes the time elapsed in seconds since the beginning of the episode, to provide information on the duration of turns of speech. In the right column, brackets indicate overlapping speech. The two speakers are Annie and Betty (all names are pseudonyms). In Line 1, Annie reads the question out loud and the two students take some time to think about a response. In Lines 2 and 3, they do not initially agree as to which bullet to select, "yes" or "no." In Line 3 Annie asks rhetorically whether temperature imitates solar activity, answering her own question negatively. In Line 4, Betty signals disagreement, while nevertheless expressing some new doubt in that it may only imitate it partially. In Lines 5 and 7 Annie contrasts an imitation that is (merely) general in some way with a waviness that shows lack of (authentic) imitation. In Lines 6 and 8 Betty agrees but it is unclear whether this agreement is in regard to the general imitation or to the lack of imitation in waviness. In Lines 7-9 Annie elaborates further, characterizing the waviness in terms of some curve being especially "spikey." She appears to indicate the Total Solar Irradiance Yearly, since it is the most erratic-looking. In Line 10, Betty at first goes back to her initial pick of, "yes," despite having just agreed to what Annie had just been saying about the waviness. But after a pause, she assents to Annie's preferred answer. In Line 11 Annie follows up by elaborating on the lack of dependence in terms of not fitting. Later, after Line 11, Annie and Betty wrote, "The temperature and solar activity do not match in terms of "fitting together" because their graphs are not aligned, the temperature is not dependent on the solar activity." Betty appears to initially construe imitation in terms of a correspondence between the darker lines up to 1960 ("for a little bit"). What is uncertain, then, is the permanence of this relation between 11-year running means. But Annie construes imitation in terms of how erratic the light lines are. What is uncertain is how well measures remain stable from year to year. By virtue of their discussion these competing and complementary notions of imitation and uncertainty become increasingly visible to them both.

Table 1: Discussion around the claim prompt for the Solar Irradiance task

Line #, seconds, Speaker	**Talk and Interaction**
Line 1, 0, Annie	(Hovers cursor over the bullets for "yes" and "no." Reads Question #1 out loud.) *Based on the graph, is Earth's temperature dependent on the level of solar activity?* (Pauses, makes mock music sound)
Line 2, 13.9, Betty	*Yeah.*
Line 3, 14.8, Annie	*Yes? Does it like imitate it? It [doesn't imitate it.]*
Line 4, 22.3, Betty	*[A little bit.] A little bit.*
Line 5, 24.4, Annie	*In terms of like general but like [waves],*
Line 6, 26.6, Betty	*[Yeah]*
Line 7, 27.1, Annie	*no. Do you see it?*
Line 8, 28.4, Betty	*Yeah.*
Line 9, 28.6, Annie	*It does it really spikey. These are like mmm mmm mmm* mmm (Tone rises and falls). *So, yes or no?*
Line 10, 34.7, Betty	*Yes.* (Pauses for 6 seconds) *No. No, I don't think so.*
Line 11, 43.8, Annie	*Cause they don't fit.*

This short episode was selected due to the two senses of imitation and uncertainty students found within the graphs. Their initial opposing responses are due to differing interpretations as to which features of the graph are most relevant to the question of dependence between quantities. Betty attends to the similarity of the long-term slopes of the 11-year average lines (dark) whereas Annie attends to the relative noisiness of the yearly data (light-colored lines). Both take agency for basing arguments in terms of the evidence (as opposed to searching for a received, normative, correct answer). Uncertainty for them is not akin to doubt (personal) but is related to the vicissitudes of the phenomena (external). That said, Annie appears to be more committed to her initial view and also appears to be more articulate and persuasive. On this reading of events, Betty defers to Annie in a way that abdicates some agency for attributing uncertainty to natural phenomena.



Line 1, 0, Candy	*Okay,* (reading the prompt) *Which line best shows what you think will happen in the future?*
Line 2, 3.2, Debbi	*Okay, it completely depends. It'll do this or this if we can clean up our act. It will do this if we can't, which I feel like this is more likely. Numeral A.*
Line 3, 21.2	(off topic)
Line 4, 29.6, Candy	*I would say actually B* (points with cursor), *because we're going to clean up our act.*

Figure 2. The Temperature Trend Task and Student Talk.

Uncertainty in the temperature trend task: Can we clean up our act?

This next short episode has been chosen to illustrate an additional sense of uncertainty students may identify. The graph in Figure 2 indicates three potential future trends, all seen in comparison to the (known and established) trend up to 2008. As with the graph from the earlier episode, the uncertainty involved in year-to-year fluctuations is managed by means of a running trend. But there is a new form of uncertainty here about things yet to happen. Prior to Line 1, Debbi had already asserted that outcome A was more likely while Candy expressed doubt about this. Then, In Line 1, Candy rereads verbatim from the prompt. In Line 2, Debbi indicates two possibilities, both involving the intervention of humans, finding the more pessimistic one more likely. Here she explicitly mentions likelihood as a feature of her argument. In Line 4, Candy asserts a contrary and more optimistic option in response to this likelihood assertion. As they continued with their discussion beyond Line 4, Candy's more optimistic view prevails. Later, after Line 4 they typed in their written response: "We think that by then, green technology will be advanced enough to help stabilized temperatures and greenhouse gas levels." Candy was initially tentative about how to characterize future uncertainty, but eventually adopted Debbi's sense that it depends on human actions. Upon doing so, she then convinced Debbi to reverse her view as to how human intervention will likely transpire. In making this explanation they grappled with how to manage uncertainties in projections about future events. So, they progressed from discussions of possibilities (A or B) to criteria for choosing (which is more likely) to some explanation as to why this would be so (green technology). In so doing their attributions of uncertainty became more grounded in explanation of phenomena (external) while the uncertainty itself become progressively delimited.

Discussion

Under ordinary circumstances textual responses are the only traces of activity preserved for teachers or for researchers. The screencasts help to make visible the various ways students do discursive work toward achieving agreement. This work is largely lost in the textual responses. Student progress in both episodes appears to have been facilitated by the teacher's organizational decision to assign students to collaborate and discuss in pairs—consistent with recommendations of the online lesson providers. The speech we witness occurs because the two students have been given the task of formulating a consensus before submitting a textual response. This underscores the value of having students collaborate as they work on online lessons like these.

Previous research has shown that students can engage to some extent in climate change lessons that make uncertainty an explicit aspect of scientific practice (Pallant & Lee, 2015). As students grapple with uncertainty they tend to either attribute uncertainty to what Pallant and Lee (2015) describe as "personal" sources or to "scientific" ones. That is, students locate uncertainty either in their own limitations or in aspects of real world phenomena, as expressed in data from graphs and model-simulations. Those who attribute uncertainty to scientific sources are much more likely to make "correct" or normative claims about climate change phenomena. Though preliminary in scope, this analysis sheds some light on the means by which students can migrate from an internalized to externalized (scientific) sense of uncertainty.

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Engaging Everyday Science Knowledge to Help Make Sense of Data

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Abstract: Making sense of data to inform decisions is an important skill emphasized in current curriculum documents (NRC, 2012). Making sense of data through personal experiences and prior knowledge is one way that students can begin to understand multiple and unfamiliar data sources. This paper examines how middle school students used different data sources when engaged in a collaborative problem solving activity using a multi-touch table during classroom science instruction. In this study, we found that students made personal connections when talking about data. Students engaged in data talk across all conversation quality levels, but the ways students interacted and talked about data varied. Connecting to students' everyday experiences could provide an access point for more complex science content understanding and synthesis and improve student data literacy skills.

Keywords: collaborative learning, data literacy, contextualizing science instruction

Introduction

Researchers report that students struggle to make sense of data. They have difficulty making sense of graphs and patterns (Schauble et al., 1995), they draw conclusions without evidence, and do not use data to support their claims (Sadler, 2004). Students' preferentially use personal knowledge and experiences to explain scientific phenomenon, rather than data (Germann & Aram, 1996). Researchers also identify the need to connect school science to everyday experience, recognizing that learning in school can be irrelevant or abstract (Aikenhead, 2006). This issue can be addressed through place based, problem based, and contextualized curriculum efforts (Rivet & Krajick, 2008; Warren, et al., 2001) that aim for more "connected science" (Bouillion & Gomez, 2001). Engaging students in the analysis of data is one way to help students make connections between school and everyday life, and improve data literacy and the relevancy of science information. This paper examines how students make sense of data by examining the conversations students have around a contextualized science task with everyday implications—how food choices impact the environment.

Involving students in tasks that address real-world problems that they can authentically connect with may engender interest and motivation; there is also evidence that constructing understanding using technology in groups improves learning outcomes (e.g., Mercier & Higgins, 2013). Collaborating provides learners with opportunities to identify patterns and communicate with others to understand a process, create a product, or reach consensus. Group activities, when properly structured, enable students to discover deeper meaning in the content and improve thinking skills. Effective collaborative activities draw on social constructivist frameworks, and often use ill-structured problems—those tasks which engage students with higher-level content that is thought-provoking, difficult to understand, and have multiple possible answers (Barron & Darling-Hammond, 2008).

Computer-supported collaborative learning is one way that students can access and make sense of multiple data sources at the same time. Multi-touch tables allow multiple users to manipulate data directly, and permit more equitable participation, supporting the construction of joint knowledge about a problem (Mercier & Higgins, 2014). Multi-touch tables can provide access to multiple data sources simultaneously, so students have the opportunity to make sense of patterns and relationships between data that is otherwise difficult to synthesize.

We hypothesized that connecting to students' everyday experiences through the use of a contextualized data-driven activity could be one way to use students' prior knowledge as an access point for understanding more complex science content. This study was designed to identify and characterize the conversations around data when working on a collaborative task using a multi-touch table, after six days of classroom instruction. The research questions addressed in this paper are:

1) How do students talk about data when working with multiple sources of data on a multi-touch table?
2) What data topics do students discuss when working on a task focused on the footprint of food?
3) What is the level of data synthesis reached when students engage in a data-driven collaborative task?

Methods

This study was designed as the first phase of a design-research project. Members of the research team led seven days of classroom activities focused on climate change. The activity that is the focus of this paper, took place on the sixth day of the intervention.

Study participants were drawn from 63 students from three 7th and 8th mixed-grade science classes at a local selective public school. All students participated in all activities; data was collected from 11 groups of students, where every student in the group had parental consent to participate.

The *Food for Thought* app was created to be used on large, horizontal multi-touch screens, and designed as an ill-structured problem, with many possible answers to encourage discussion within groups. The task centered around the creation of an environmentally sound meal. Twenty-two different foods were visible on the screen (see Figure 1). For each of the foods, the water footprint, carbon footprint, calories, and cost were calculated. As students placed the food on a dinner plate, the metrics for each category appeared on individual bar graphs for 3 types of data, and as a list for price. All members of the group could interact with multiple data sources at once. The dinner plate remained anchored in the center of the screen while the individual graphs and foods could be moved anywhere on the table. The graphs could be reduced or enlarged in size, and rotated.

Figure 1. Food For Thought App Screenshot.

During the preceding class sessions, students covered content related to the carbon and water footprint of food through a variety of activities. While using the application, students were led through three activities. Students were asked to assess and coordinate the various production costs of food using the data provided in the app and to apply that information to each task. Tasks, which increased in complexity, were 1) create your favorite meal; 2) create a dinner that includes a protein; students were asked to swap out proteins and evaluate the data; 3) create a meal that you think is best for the environment. For the purpose of this paper, only task 3 will be analyzed.

Data sources and analysis

Data was collected in a lab classroom that was equipped with video recording equipment, due to technical issues with one video, only 10 videos were used; videos were transcribed in playscript form. Emergent coding schemes were developed to account for students' discourse around data. The analysis proceeded in five steps. First, turns were coded to identify data-focused talk. Next, the data talk was coded as either derived from the information contained in the app, or from students' prior knowledge (Table 1). Two researchers coded 20% of the transcripts for data talk with an inter-rater agreement of 98% and Cohen's Kappa of .96.

Table 1: Data definitions as applied to turns

Code	Definition	Examples
App Data	• Values of the food from the app with or without unit designations • Information from within the app • Direct responses after app data statement	• "Beans are 142. What about eggs?" • "Steak is high", "The price went up", "Steak, oh no" (pointing at the graph and looking at the values) • "Steak has a lot of carbon", "No it doesn't"
Prior Knowledge	• Comments based on data not included in the app • Direct responses after prior knowledge statement	• "Beans are a good source of protein" "Beans are healthy", "Spaghetti is bad for you" • "Bananas have to be imported", "Yeah, I know"

In the third stage, data talk was organized by episodes of data talk; episodes were defined as discrete conversation turns about the same topic. Conversations that were happening concurrently were considered to be within the same episode. Data episodes were chosen as a unit of analysis in order to examine when and how personal data was incorporated into conversations and to identify instances of data synthesis. For the fourth stage, data episodes were grouped by the data type contained in each episode; app data only, prior knowledge data only, or as mixed data, when a data episode contained both prior knowledge and app data. Two researchers coded 30% of the transcripts for reliability, with a Cohen's Kappa of 0.87. Because the length of a data episodes varied, a variable was created to account for the proportion of total turns. Each data topic from the table (water, carbon, calorie and cost) that was referred to during the task was counted each time it was used explicitly, identified either by name or its associated value.

A second emergent coding scheme was applied to data episodes to characterize how students referenced data in conversation, and the highest level of synthesis achieved in each episode. This coding scheme identified data synthesis as Low, Medium or Medium-High (Table 2). A synthesis designation, achieved by tabulating episodes, includes both the most frequent and the highest level each group achieved in combination. Thirty percent of the transcripts were coded independently for episode by a second researcher; inter-rater agreement was 82% and Cohen's Kappa was 0.79.

Table 2: Data synthesis coding framework

Category	Description	Examples
Low	No explicit reference to data in conversation, or the data value is read directly from the table without reflection (an extension of an idea from the data)	"…rice doesn't have much"; "bananas were high" "605"
Medium	Explicit use of data from table or personal experience without specific values; some reflection using data	"So the thing that needed the most water was steak"
Medium High	Data talk is explicit and connected to more than one data type. Some data synthesis.	" if we are going to make it for three meals we need more than 600 calories, and it uses a lot of water"

Results

The total proportion of data talk by turn varied among groups, with a range between 14% (Group 8) and 54% (Group 6). Data talk comprised a little more than one quarter of the turns of group discussion for half of the ten groups. Results from data topic (CO_2, H_2O, cost, calorie) tabulation indicated that all but one group refered to at least one data topic explicitly during task. Four out of ten groups referenced two topics, with half of the groups using three data topics while building an environmentally friendly meal. None of the groups referenced all four data topics. Data topic(s) discussed varied across groups. CO_2, and H_2O data were referenced by six groups, while cost was mentioned by two groups, and referenced least. Only one group (Group 6) referred to a data topic (CO_2) twice during the task. None of the groups used the unit of measurement associated with either water (gallons) or carbon (CO_2 equivalents), in discussion during the task.

Groups engaged in between 3 and 5 episodes of data talk while participating in the task (Mean = 3.90, SD = 0.74). Data conversations that resulted from information from the app alone characterized almost half of the 39 total data talk episodes (49%). Eight of ten groups used prior knowledge when making sense of the data, either in a stand alone statement (15% of data talk by episode) or as part of discussion which integrated prior knowledge with the data from the table (36% of data talk by episode). When taken together, data from prior experience, alone or in combination with table data, constituted 51% of the total data talk when analyzed by episode. One group (Group 8), did not use prior knowledge at all during the activity, instead relying solely on information provided within the app to make decisions. Three groups (4, 6, and 7) did not reference the table data explicitly in conversation, unless it was used in combination with prior knowledge when building a meal. Two of these groups (4 and 6) were the only groups that achieved medium-high synthesis of the information during the task. The remaining group, (Group 7) reached medium synthesis during data conversation.

Nine of the ten groups engaged in low synthesis data talk, which made up 41% of the total data episodes identified. While all groups participated in one or more instances of medium quality data talk (51% of all episodes), only two of the ten groups (Groups 4 and 6) engaged in medium high data synthesis,which was identified in only three episodes, comprising 8% of the total. Group 4 did not engage in any low synthesis data talk, and instead employed medium and medium high talk in discussion. All episodes of data talk for this group involved mixed data talk, where data from both the app and prior knowledge were used in conversation during the task. Group 6 used prior knowledge in one of three data episodes, and mixed data talk in the remaining two episodes.

On average, groups that engaged in higher levels of synthesis also engaged in more data talk; groups that reached lower synthesis designations talked less. Four groups were identified as low-medium synthesis, and mean percent of data talk across these groups was lowest (M = 28.80, SD = 8.79). While all groups had conversations with at least one episode of medium data talk, the four groups characterized by the largest proportion of medium synthesis data episodes also comprised the group with the intermediate amount of data talk (M = 41.00, SD = 10.03). The two groups that were classified as attaining medium-high synthesis also sustained the highest percentage of data talk on average (M = 48.69, SD = 12.29).

Conclusions and implications

In this study, results indicated that amount of data discussion, the explicit use of data in discussion, and synthesis across data topics was low. We found that prior knowledge was an important component of the data discussions that did take place, and that eight of the ten groups used prior knowledge when talking about data, across all conversation synthesis levels. This aligns with prior research that indicates that connections to everyday experience may be one way that students interact with complex data (Rivet & Krajcik, 2008; Warren, et al., 200l). It is possible that the students who were less experienced in making claims from data used prior information as an access point for understanding the novel data, and that those students that reached higher data synthesis levels also used prior knowledge, or the combination of prior knowledge and data from the app, to grapple with a socioscientific issue, although further research is needed to examine this finding. We also found that while the number of data episodes was similar across groups, the amount of time spent in data conversations was correlated with the level of data synthesis achieved; groups that talked longer also reached higher levels of synthesis.

These results indicate that some groups of students engaged in some complex discussion of data sources related to the impact of food on the environment, using both the data provided to them and their own prior knowledge. Future research will examine how an individual student’s prior knowledge supports and sustains, or hinders, a groups’ conversation with and about data. This study will inform further development of the task to support the incorporation of prior knowledge, and how the task can more fully support students’ engagement with data, while still maintaining an ill-structured format.

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Productive Knowledge Building Discourse Through Student-Generated Questions

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Abstract: Working on students' authentic problems is emphasized in Knowledge Building theory and pedagogy, as it is perceived that a failure to deal with such problems may result in a failure of knowledge building. This study is focused on questions students asked in a knowledge building environment, in order to examine how issues students cared enough about to pose as questions help knowledge building succeed. Comparing question threads (threads started with questions) and non-question threads (threads that did not start with questions), we noticed that problems posted by students engaged the community in a sustainable and progressive discourse, which is central to collaborative knowledge building. Moreover, the quality analysis of the data revealed that the threads starting with questions were more likely to end up with productive threads compared to the non-question threads.

Introduction

Knowledge Building is an idea-centered pedagogy where students create knowledge through engaging in complex socio-cognitive interactions as epistemic agents (Scardamalia & Bereiter, 2006a). Knowledge Building is based on 12 foundational principles, such as *community knowledge, collective responsibility*, *idea diversity*, and *improvable ideas* (Scardamalia, 2002; Scardamalia & Bereiter, 2006a). As a principles-based pedagogy, knowledge building classrooms are "profoundly different from even the best of traditional and modern classrooms" (Scardamalia, 2002, p. 77). Engaging students in *real ideas, authentic problems* (Scardamalia, 2002), which is one of the critical principles of Knowledge Building, means focusing on ideas that students themselves come up with, and the questions that they actually care about—not what others decide are engaging. Students in knowledge building classrooms are given high levels of agency, so that they actively mine the world around them for interesting issues and challenges. In pursuing *real ideas/authentic problems* that arise from their efforts to understand the world, students engage in sustained creative work with ideas through *knowledge building discourse* (Scardamalia & Bereiter, 2006a) -- another Knowledge Building principle. *Knowledge building discourse* is central to collaborative knowledge creation, because learners construct their knowledge, express their opinions, values and feelings through discourse (Bereiter & Scardamalia, 1993; Tsoukas, 2009). Engaging in sustainable knowledge building discourse will help students dig down the issues, which is part of idea improvement (Scardamalia & Bereiter, 2006b). Therefore, the more students are engaged in knowledge building discourse, the higher the chance of knowledge building success. It is perceived that questions are propulsions that push the dialogue forward (Resendes, 2014); *factual questions* (who, what, where, and when) are required for explanation-seeking dialogue as they increase the coherence of theories, and *explanatory questions* (why/how something works) push the dialogue forward in new and promising directions (Resendes, 2014). This exploratory study investigates the extent to which students introduce their authentic questions in their knowledge building discourse, how the peers pursue these peers-generated questions to reach a deeper understanding of the world, and how these contributions impact collective idea improvement.

Method and data analysis

The dataset used for this study is comprised of the online discourse of one class of Grade 4 students exploring "rocks and minerals." Student dialogue consists of 262 notes generated by 20 students over the course of 4 months and archived on Knowledge Forum®-- a knowledge building environment built specifically to support collaborative production and refinement of the community's knowledge (Scardamalia, 2004). This study employs the "ways of contributing" framework, which was developed to code students' types of contributions to knowledge building discourse (Chuy et al., 2011). This framework was chosen because it offers a systematic inventory of ways of contributing that can shed light on how knowledge building discourse moves toward knowledge objectives. This framework categorizes students' contributions into six main categories (e.g., questioning, theorizing, obtaining information) and 24 subcategories (e.g., proposing an explanation, improving an explanation, synthesizing information from resources).

For this analysis, student contributions were also assessed according to their role in discussion threads. In this study, a thread is defined as a set of connected notes, or even a single isolated note. This definition is compatible with Hewitt and Teplovs's (1999) and Hewitt's (2005) description of a discussion thread, which considered one single disconnected note as a thread. In Knowledge Forum, students are able to post individual notes into the discussion space, and are also able to create 'build-on' notes, which are contributions that link directly onto an existing note. Build-on notes are indicated by an arrow that connects the two notes on the screen. In the dataset for this work, there were a total of 91 online discussion threads. The discussion threads were first categorized into two categories: I) threads starting with students' questions, and II) threads starting with non-question notes. Among these 91 threads, 68 threads were *question threads* (threads started with questions), while 23 threads were *non-question threads* (did not start with a question). Applying the ways of contributing scheme, two raters coded all the notes and achieved an agreement rate of 99.57%. The result of the coding of the notes was then used to categorize threads starting with questions. Based on the results of the coding, 33 threads were identified as *factual-question* threads (threads started with factual question--e.g. what is a rock?), and 37 threads were identified as *explanatory-question* threads (threads started with explanatory question-- e.g. how are rocks made?). Two threads were identified as starting with both factual and explanatory questions (e.g. where did Lava come from? and how it was formed?) In order to answer the research questions, ANOVA analysis and qualitative analysis were conducted. The ANOVA analysis was conducted in order to examine if and how the length of these three types of threads differ. The length of threads is an indicator of sustainable discourses and can indicate the potential of a discourse to be productive, as the depth of inquiry in a short thread is usually limited (Law, Yuen, Wong, & Leng, 2011, p. 64). However, it is very important to realize if the discourse is really moving toward a knowledge objective, despite thread length (Bereiter, Scardamalia, Cassells, & Hewitt, 1997). Therefore, qualitative analysis was conducted in order to qualitatively examine which types of the threads demonstrated idea improvement. Chen, Resendes, Chai, and Hong (2017) employed the ways of contributing schema, and distinguished productive and non-productive threads using the *improving an explanation* subcategory of the *theorizing* category. If a contribution was found to be *improving an explanation,* it was helping to move the discussion towards a knowledge goal and increasing the explanatory coherence of collective ideas (Thagard, 1989, 2007). If any note in a thread fell under the *improving an explanation* subcategory, that thread was considered a "productive" thread, otherwise, it was considered non-productive. We employed Chen and colleagues' method to identify which threads are productive.

Results

Sustainability of threads

Results show that almost 78% of the non-question threads did not have any responses, while only 30% of the factual-question threads and 24% of the exploratory-question threads had no responses. These isolated discussion threads form threads with size 1. Moreover, almost 9% of the non-question threads had one response (threads with size 2), while almost 36% of the factual-question threads and 19% of the exploratory-question threads had one response (Figure 1).

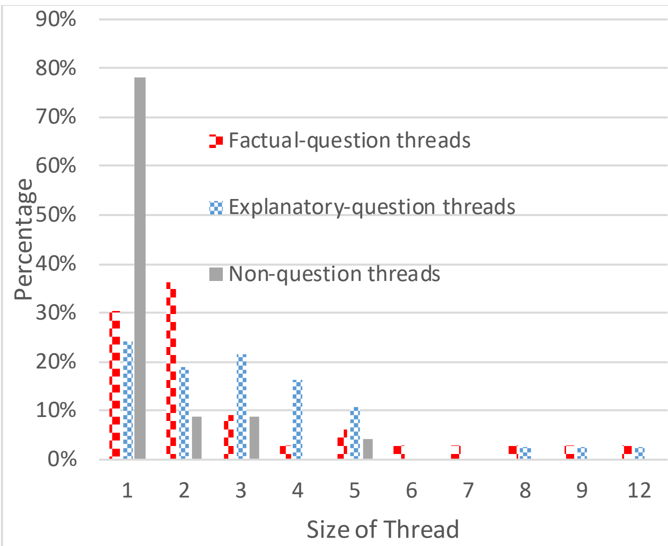

Figure 1. Comparing the size of the threads.

As Figure 1 demonstrates, the maximum size of a non-question thread is 5, while the maximum size of a question thread (either factual or exploratory) is 12. Therefore, the results show that compared to non-question threads, threads starting with factual questions and exploratory questions tended to be more sustainable--a quality which can potentially push discourse toward other types of contributions, resulting in productive discourses.

As Table 1 shows, the ANOVA analysis revealed that the size of the factual-question threads and explanatory-question threads do not differ significantly. However, the size of both factual-question threads and explanatory-question threads differ significantly with the size of non-question threads; non-question threads have significantly fewer responses compared with the other two types of threads that started with questions.

Table 1: ANOVA analysis of the size of the three types of threads

(I) Types of notes that lead threads	(J) Types of notes that lead threads	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Non-question	Factual	1.565*	.610	.032	.11	3.02
	Explanatory	1.808*	.597	.009	.39	3.23
Factual	Explanatory	.243	.538	.894	-1.04	1.53

Productivity of threads

The results of the productivity analysis show that among all the 91 existing threads, 11 threads were identified as productive threads, while the other 80 threads were coded as non-productive threads. Among these 11 productive threads, five threads (45.5%) were coded as explanatory-question threads and four threads (36.4%) were identified as factual-question threads. Only two threads (18.1%) were coded as non-question threads. Below you can see an example of a productive knowledge building thread. (Typos in students' notes have been revised).

[Note A] *How are rocks made?*

[Note B] *My theory is that rocks are made by magma drying and being compacted.*

[Note C] *My theory is that sand is in the sea starts to form in a number of years and finally it [a rock] forms.*

[Note D] *Some rocks are made by sand hardened sand.*

[Note E] *My theory is that wherever the rock is found is probably where it is made.*

[Note F] *The rock that I brought in is made out of pure hardened sand*

[Note G] *There were a whole lot of volcano and the ash came and lava so the lava cooled and you have your rock.*

[Note H] *Rocks are made by minerals coming together over many millions of years.*

In the above thread, the thread starts with an Explanatory Question [Note A]. Based on the coding, Note B and Note C are considered as improving an existing theory of the community, Note E is coded as proposing a theory, and Note G and Note H are coded as supporting a theory. As there are two notes in this thread that are coded as "improving a theory" notes, this thread is considered as a productive thread.

The thread shown below is an example of a non-productive thread (size 2) that does not show evidence of knowledge advancement:

[Note A] *Some scientists think that the thing that exploded was remains of an old universe what if that universe had life the old life from the old life particles C.*

[Note B] *i think that's true BUT, what does c mean?*

Discussion and conclusion

The results of the analysis show that threads not starting with students' questions were not sustainable enough to move the discourse toward a knowledge objective. On the other hand, questions (either factual or explanatory), made students' discourses more sustainable, which is a favorable phenomenon for Knowledge Building. The results of the productivity analysis show that, in this case, the chance of having productive dialogue in threads starting with questions is higher than the chance of having productive threads in non-question threads. As presented above, there were nine question-driven threads that were coded as productive, while there were only two non-question threads that were coded as productive threads. Therefore, only 18% of the 11 existing productive threads started with non-question notes, while 82% of the all productive threads of the community were threads that started with students' questions.

As described before, the length of the "factual question" and "explanatory question" threads did not differ significantly. Moreover, we identified five productive threads starting with explanatory questions, while four other productive threads started with factual questions. These findings do not show any significant difference between factual questions and explanatory questions, in terms of their effects on improving the community knowledge. In fact, the results suggest that giving students sustained opportunities to pose original questions may help them engage in sustainable discourses that may result in productive discussions.

These findings indicate that computer supported knowledge building environments provide the opportunity for students to express their puzzlements in order to mine the world around them. On the other hand, these questions encouraged peers to engage in sustainable discourse to dig down the issues and finally generate/improve theories. As a result, dealing with students-generated questions which they really care about helps knowledge building succeed by engaging the community in sustainable and productive discourses. Replicating the study with a richer dataset from different grade levels will be the focus of our next investigation, in order to examine if the same phenomenon occurs.

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Building Arguments Together or Alone? Using Learning Analytics to Study the Collaborative Construction of Argument Diagrams

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Abstract: Research has shown that the construction of visual representations may have a positive effect on cognitive skills, including argumentation. In this paper we present a study on learning argumentation through computer-supported argument diagramming. We specifically focus on whether students, when provided with an argument-diagramming tool, create better diagrams, are more motivated, and learn more when working with other students or on their own. We use learning analytics to evaluate a variety of student activities: pre and post questionnaires to explore motivational changes; the argument diagrams created by students to evaluate richness, complexity and completion; and pre and post knowledge tests to evaluate learning gains.

Introduction

Having students learn argumentation and critical reasoning through supported argument diagramming holds great promise, but it is not clear whether working alone or with others is better for learning. In this paper we aim to assess whether students produce better argument diagrams, are more motivated, and learn more when working in small collaborative groups versus working individually. Related research has shown that the construction of visual representations, such as diagrams, may have a positive effect on understanding, deeper learning and other important cognitive skills, including critical thinking and argumentation (Harrell & Wetzel, 2013). In addition, collaboration has been shown to be beneficial, in particular, for learning to argue and co-construct knowledge (Scheuer, McLaren, Harrell, & Weinberger, 2011). Thus, providing students with a tool that can support both argument diagramming and collaboration might result in deeper learning and, potentially, in helping students become better arguers.

In our research, we use learning analytics to study various aspects of the learning activity such as: a) pre and post questionnaires to explore motivation; b) the richness, complexity and completion of created argument diagrams; and c) pre and post knowledge tests to evaluate learning gains. Learning analytics is defined as "*the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs*" (LAK 2011, Call for Papers). To explore the advantages that a collaborative software tool [LASAD (Scheuer, Niebuhr, Dragon, McLaren, & Pinkwart, 2012)] can provide to college-level students, we conducted a small classroom study with undergraduate students. Prior studies of collaborative argumentation have almost exclusively been lab studies of short duration. However, our aim was to study the benefits of a full semester's use of the argumentation tool. The study compared the practice of groups of 2-4 students who collaborated with LASAD for learning argumentation to students who worked alone. Our overall goal was to answer the research question: *Does collaborative, computer-supported argument diagramming lead to more motivation, better understanding of arguments, and better argumentation skills than individual, computer-supported argument diagramming?*

Related work

Students need to learn to argue and debate in a well-founded, rational way in order to succeed in a variety of academic subjects, including science, philosophy, and writing. Argumentation skills are vital to everyday life in our complex, democratic society. Yet, these skills are often lacking in students and, hence, need to be explicitly trained and exercised. Philosophy in particular – the topic we study in this paper – is an academic discipline that emphasizes argumentation skills. A key task for learning about argumentation is argument diagramming in which students take arguments, read them carefully, and reconstruct the arguments in a graphical form. Argument diagramming, supported by computer-based tools, plays an important role in introductory philosophy courses (Harrell, 2016). There are a variety of benefits to argument diagramming, including that the diagrams make arguments explicit and inspectable. Students typically work individually, not collaboratively, on argument diagramming exercises. However, we believe that students can benefit from discussing arguments and working collaboratively as they diagram. Literature in the Learning Sciences has shown the potential benefits of collaboration, such as the benefits of explanation (Fonseca & Chi, 2011) and co-construction of knowledge

(Webb, 2013) and, in particular, how these benefits have been observed in collaborative argumentation and learning to argue, when the argumentation process is structured (Weinberger, Stegmann, & Fischer, 2010). Thus, providing students with a tool that can support both argument diagramming and collaboration might result in deeper learning about argumentation and, potentially, in helping students become better arguers.

Methodology and study setup

The study took place as part of an "Introduction to Philosophy" course over a four-month semester, with three intervention sessions throughout the semester. The participants were university students (17 - 21 years old) from various departments (computer science, engineering, social sciences, etc.). The goal of the intervention was to introduce students to argument diagramming. We studied the practice of 19 students (8 females, 11 males) who completed the course. The students were assigned to one of two conditions: the experimental (Collaborative) condition, where 11 students worked in groups of 2-4 members and the control (Individual) condition, where 8 students worked individually. Both conditions had to construct three argument diagrams for three different theses (e.g. the "The Impossibility of Moral Responsibility" by G. Strawson). The participants had to read the arguments, identify the premises and formulate a conclusion through a diagrammatic representation that reflects the underlying relations between them. Overall we studied 32 argument diagrams: 21 diagrams from the individual condition and 11 diagrams from the collaborative condition. The 8 individuals created 3 diagrams each, resulting in 24 diagrams overall. However, 3 of 24 diagrams were not completed (the participants were absent). Similarly, 4 groups had to create 3 diagrams each, resulting in 12 diagrams overall. In one case, only one group member was present for the activity; thus, this diagram was left out of the analysis. The creation of the diagrams was supported by a web-based argumentation system (LASAD) that allows users to argue in a structured fashion using graphical representations (Scheuer et al., 2012). LASAD supports both individual and collaborative use (two or more users working synchronously on the same diagram) and it was designed to specifically support argument diagramming.

For our study, we used questionnaires to assess motivational aspects adapting 13 questions from the MSLQ – Motivated Strategies for Learning Questionnaire – instrument (Pintrich & De Groot, 1990) to capture disposition towards classwork. The questions were rated on a 7-point Likert scale. We also studied potential learning gains on the basis of pre/post knowledge tests and by evaluating the resulting argument diagrams in terms of correctness and completeness. Finally we used metrics of activity based on the actions logged – LASAD records detailed user actions – to analyze the diagrams created by the students, such as the number of actions a user performs during the activity and time on task. To assess the size and complexity of the diagrams, we used metrics such as (1) the number of objects in a diagram (*#objects*), (2) the number of relations in a diagram (*#relations*), (3) the sum of objects and relations, (4) the ratio of relations per object, and (5) the cyclomatic complexity of the diagram, which is widely used to indicate complexity of software programs. The cyclomatic complexity is defined as: $M = E - N + P$ (McCabe, 1976) where: E is the number of edges of the graph, N is the number of nodes of the graph and P is the number of connected components. We made the assumption that diagrams can be perceived as algorithmic flowcharts and therefore the cyclomatic complexity can provide a measure of the diagram's complexity. The number of objects and relations of a diagram and their sum has been used in other studies as an indication of the size of a diagrammatic representation (Slotte & Lonka, 1999), while the ratio of relations per object is as an indicator of the level of detail (Chounta, Hecking, Hoppe, & Avouris, 2014). We refer to this process of measurement, collection, analysis and reporting of data as "learning analytics" since its purpose is to provide insight and suggestions of how learning occurs within the context of collaborative argumentation diagramming (LAK 2011, Call for Papers).

Results

From the analysis of the argument diagrams, shown in Table 1, it was evident that the groups constructed larger (25% more objects) and more elaborate diagrams (38% more relations) than the individual participants. On average, the argument diagrams created collaboratively were more detailed (higher ratio of relations/objects) and more complex (higher cyclomatic complexity) than the diagrams of individuals. Group participants performed fewer actions in total than the individuals but they spent more time on the task. (Given the small number of participants, we acknowledge that further statistical analysis is not helpful).

We expected the groups to construct the argument diagrams faster since more people contribute to the common goal, but this was not confirmed. This might indicate that group participants spent time discussing and reflecting on the work of their peers. However, these metrics do not necessarily indicate diagrams of better quality. To that end, the course instructor and a student helper rated the diagrams for correctness and completeness on a [0, 5] range. The comparison between conditions showed that the diagrams created by groups were rated higher than those of individuals ($Grade_{Collaborative} = 4.45 > Grade_{Individual} = 3.875$).

Table 1: Diagram-related and user-specific metrics - on average - for the diagrams constructed collaboratively and for the diagrams constructed by individuals

Conditions (N=19)	Diagram-related metrics				User-specific metrics		
	#objects	#relations	#relations/ # objects	cyclomatic complexity	#actions	Time on task (minutes)	actions/time on task
Collaborative (N=11)	11.27	14.00	1.22	3.73	60.30	20.96	2.91
Individual (N=8)	8.4	8.0	0.95	2.45	68.33	17.89	3.88

With respect to motivation, as assessed by pre-questionnaires, participants were positively motivated towards class work, including usefulness and importance of the course. Individuals scored, on average, higher ($Mot\_pre_{Individual} = 5.35$, $SD_{Individual}=0.22$) compared to group participants ($Mot\_pre_{Collaborative} = 5.18$, $SD_{Collaborative} = 0.44$). With respect to the post-questionnaires, participants' motivation decreased. The picture was similar for both groups ($Mot\_post_{Collaborative}=4.9$, $sd_{Collaborative}=0.27$) and individuals ($Mot\_post_{Individual}=4.98$, $sd_{Individual} = 0.39$). The difference in motivation between conditions was maintained but the standard deviation increased for the individual participants (5 out of 8 participants rated motivation lower in post than pre-questionnaire). Both group and individual participants rated lower the items referring to curriculum (e.g. "*I liked what I learned in the class*"), indicating that their expectations might not have been met. Participants who worked in groups maintained the same attitude with respect to giving up and they gave higher ratings to items referring to perceived personal performance (e.g. "*I believe I did very well in this class*"). This might indicate that working in groups made participants feel more confident about their performance and achievement in terms of grading and it also encouraged them to insist on their tasks instead of giving up.

To evaluate learning gains, participants took knowledge tests before and after the completion of the study. These tests examined performance on five dimensions (Diagram Quality, Conclusion, Premises, Connections, Argument Evaluation) and were rated on a [0, 3] range. The knowledge gain was computed as the difference between pre and post knowledge tests. Table 2 shows the comparison between the performance of the groups' participants and the performance of individuals. The participants who worked collaboratively performed better in the post than in the pre-knowledge tests, attaining a knowledge gain of 0.33 on average. The participants who worked individually scored similarly in the pre and post-knowledge tests. The participants in the collaborative condition scored the highest knowledge gain for diagram quality ($M = 0.84$, $SD = 0.29$). The individual condition participants also scored the highest knowledge gain for the diagram quality category but only half as good as the participants in the collaborative condition ($M=0.428$, $SD=0.76$). Furthermore, the individual participants scored the lowest knowledge gain for Argument Evaluation ($M= - 0.714$, $SD = 0.699$). In the same category, the collaborative condition participants scored similarly in the pre and post-knowledge test. This might be an indication that the collaborative construction of arguments has a deeper effect on students' understanding of arguments. The difference in scores between the two conditions was not statistically significant; however, as already noted, this was a study with a small N. As such, we are mostly focused on pinpointing suggestions of the effect of collaborative argumentation on learning gains and how this could be further studied.

Table 2: Results of the pre and post knowledge tests, as well as the knowledge gain between the post and pre-knowledge tests per grading category

	Pre-knowledge test		Post-knowledge test		Knowledge gain	
	Collaborative	Individual	Collaborative	Individual	Collaborative	Individual
Diagram quality	1.5	1.886	2.34	2.314	0.84	0.428
Conclusion	2.6	2.143	2.5	2.428	-0.1	0.286
Premises	2.4	2.857	2.8	2.714	0.4	-0.143
Connections	1.1	1.571	1.5	1.857	0.4	0.286
Argument Evaluation	1.4	2	1.5	1.286	0.1	-0.714

Discussion

In this paper, we presented a study of the use of computers for learning argumentation through argument diagramming. Previous research has shown the importance of argument diagramming in argumentation learning (Harrell & Wetzel, 2013). Prior research has focused on computer-supported argumentation and the benefits of computer-mediated collaborative argumentation (Scheuer, Loll, Pinkwart, & McLaren, 2010). We specifically focused on whether students, when provided with an argument-diagramming tool, create better diagrams, are more motivated, and learn more when working with other students or on their own. Our basic research question was: *Does collaborative, computer-supported argument diagramming lead to more motivation, better understanding of arguments, and better argumentation skills than individual, computer-supported argument diagramming?* To that end, we carried out a preliminary study where 19 undergraduate students used a software tool to construct diagrams based on given (written) arguments. The students were divided into two conditions: those who worked collaboratively in small groups of 2-4 people and those who worked individually. To analyze the activity we used questionnaires to explore motivational aspects, and the argument diagrams created by students and knowledge tests to evaluate learning gains.

The analysis revealed that participants were positively motivated towards the class before the study but their motivation dropped after its completion. Both groups and individual participants indicated a loss of motivation from pre to post-questionnaires on items that referred to curriculum. The drop in motivation might reflect a drop in interest about the overall course and not the argument diagramming, *per se*. Participants who collaborated in groups indicated higher motivation on perceived personal performance (e.g. "*I believe I did very well in this class*") in contrast to individuals, and they maintained the same attitude with respect to giving up when work was uninteresting ("*Even when study materials are dull and uninteresting, I keep working until I finish*"). This may be an indication that collaborative work made participants feel confident about their performance and motivated them towards completing their tasks. The collaboratively-created argument diagrams tend to be larger, more complex and were graded higher than the ones created by individuals. The participants in the collaborative condition also attained higher learning gains from pre to post-knowledge test.

Although this study was relatively small, we believe it provides insight on how to support argumentation learning through collaborative construction of diagrammatic representations. The study suggests that collaboration empowered participants with confidence and feelings of goal achievement. However, as mentioned, these results are only suggestive, due to the small number of participants. Furthermore we focused only on the activity that took place within the shared workspace but did not analyze the communication (i.e., chat messages) between group members. Additionally, since this was only preliminary research aimed at studying the effect of the tool's use, we focused on the activity of students and did not study the role of the teacher. We plan to carry out studies with more participants in future studies and to study the use of the collaborative tool in various learning designs, for example teaching argumentation through confrontation or supported by game features.

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Effects of Perspective-Taking Through Tangible Puppetry in Microteaching Role-Play

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Abstract: Perspective-taking of a wide variety of pupils or students is fundamental in designing a dialogic classroom. As a vehicle of perspective-taking, tangible puppetry CSCL can create a learning environment that reduces the participants' anxiety or apprehension toward evaluation and draw out various types of pupils or students, allowing them to learn various perspectives. A classroom study revealed that the effect of tangible puppetry role-play remained in the immediate transfer task; the participants could elicit a variety of voices from possible pupils even in the self-performed role-play, and as well as on their essay. However, the mutual feedback discussions in the third session changed significantly- as similar to the first trial. This paper discusses necessary future directions to promote better reflection and to deepen perspective-taking through the tangible puppetry.

Introduction

Designing an effective lesson leveraging dialogic pedagogy is an essential skill for schoolteachers (Mutton, Hagger, & Burn, 2011)—but even for experienced teachers, it is difficult to operationalize in a classroom. In the dialogic classroom, teachers and students address learning tasks, listen to each other, share ideas and consider alternative viewpoints together. Students articulate their ideas freely—without fear of embarrassment over wrong answers— and help each other reach a shared understanding (Alexander, 2008). The teachers need to design a dialogue to stimulate the students' thinking and advance their learning and understanding through structured and cumulative questioning and discussion, without monologic knowledge transmission. To prepare in designing a dialogue which ensures various students' participation, the teachers need to imagine a wide variety of voices of their students and possible reactions and questions (Bahktin, 1981).

Microteaching is one of the ways to practice how to implement dialogic pedagogy in teaching; however, it is not easy to achieve. One of the reasons discussed in the "apprenticeship of observation" framework (Lortie, 1975) is that student teachers and novices experienced monologic teaching as students themselves. However, we argue that there is another difficulty – excessive self-consciousness (Ladrousse, 1989) or evaluation apprehension (Cottrell et al., 1968) during microteaching. The role-play requires (student) teachers to act out young pupils in a realistic way which they may feel difficulty in, creating a tendency to play honest students who follow the teacher's instruction without questioning.

The past study discussed that tangible puppetry can serve as a powerful device for allowing people to overcome emotional or interpersonal obstacles in face-to-face role-play, and for eliciting reactions including inner emotions or unconscious experiences that they have had in a problematic situation (Mochizuki, et al., 2015). Puppetry allows each participant to obtain participant-observer balance by creating a clear separation between self (puppeteer) and non-self (puppet) as well as character (puppet) and observer (puppeteer) while playing a puppetry story, so that participants can use informal/irregular discourse more in the puppetry than in the case of normal self-performed role-plays where they rarely used informal/irregular one (Aronoff, 2005).

We argued that puppetry can be a catalyst material to elicit and learn more realistic students' reactions to foster perspective-taking of a wide variety of students, and developed a tangible puppetry CSCL system to help microteaching role-play in a puppetry format (Mochizuki et al., 2015). The system records the actions and conversations of the participants (hereinafter, the "character") on top of a transparent table (Figure 1 (a)). In Figure 1, photo (a) shows the system ready to be implemented. Each puppet or prop is attached to a transparent box with an AR marker on the bottom. Each character can express his or her puppet's condition by manipulating a switch to change the color of the LED in the box to either red or blue (Figure 1 (b)). A red LED may represent a sleeping/careless student, and blue an attentive/note-taking student. A web camera and microphone under the table record the puppets' movements and conversations (i.e., the behavior of the characters), by detecting the

AR markers. After the role-play (Figure 1 (c)), the participants can view the recorded puppetry to inspire reflection (Figure 1 (d)). The webpage displays the role-play in animated form from a bird's-eye view.

The present study aims to examine the effectiveness of puppetry microteaching role-play, especially on perspective-taking. We demonstrated the preliminary evaluation of the CSCL system by comparison with self-performed role play. This study examines an immediate transfer of perspective-taking training using the system so that we can discuss further promising ways to nurture the dialogic teaching skills.

(a) (b) (c) (d)

Figure 1. The CSCL system for tangible puppetry.

Method

Participants and design

Participants were 36 undergraduate students (Female 66.7%) in a private university Japan, studying to become elementary school teachers and taking a pedagogy course. Students were randomly assigned to groups of three, forming 12 triads. They each conducted self-performed microteaching role-play or puppetry microteaching for 10 minutes. The system described above was used to record the puppetry microteaching, and all the students in each group were video-recorded during the self-performed microteaching, both which were reviewed before the mutual feedback session. This session was conducted in the form of a discussion, lasting for 20 minutes.

To examine the effectiveness of perspective taking in the puppetry role-play, each participant enrolled in one puppetry microteaching and two self-performed microteachings; the first and third participants played the teacher in the self-performed role-plays, and the second participant played the teacher in the puppetry role-play. The rest of the participants played the pupil's role in every session in the same way (i.e., puppetry or self-performance) as the student teacher. Students playing the pupil's role were asked to act realistically, as though they were in an actual classroom. Thus, the first session was designed as the pretest, the second as the intervention, and the third as the posttest to examine the immediate transfer of the puppetry microteaching.

Each microteaching included a role-play and a reflection. Students would watch a video or an animation of the role-play for 10 minutes, and hold a discussion for 20 minutes as mutual feedback. The animation was provided by the system described above, and all the students in each group were video recorded during the self-performed role-play session. After watching the video or animation and mutual feedback by replaying the video/animation, the students wrote a short essay about what they learned through the session.

Assessment

All the microteaching role-plays and mutual feedback discussions were video-recorded and transcribed (except for one first session in a group due to lack of clear voice recording). Adapting Fujie (2000)'s coding scheme for teacher-student discourse (Table 1), we coded all of the utterances in the puppetry and self-performed role-plays to examine how the students performed ($\kappa = .827$). This scheme was designed to study how classroom discourse is organized, especially focusing on formal academic utterances versus informal or everyday utterances. We aimed to identify any differences in role-play discourse that were due to puppet use. We also analyzed the student discussions for mutual feedback, adapting slightly modified Rosaen et al. (2008)'s coding scheme (Table 2) in order to examine how the students reflected on their role-playing in both conditions ($\kappa = .723$).

Furthermore, the students' essays (except one student's essay due to lack of data) were coded from the viewpoint that each essay included student-centered viewpoints, or/and images of a variety of possible pupils' presence and reactions in an actual classroom ($\kappa = .866$). Two of the authors independently coded all the data, and coding discrepancies were reconciled by mutual agreement.

Results

The discourse analysis of the microteaching role-play shows that there are various significant associations (Table 3). The categories "Teacher-Informal," "Teacher-Double barreled," and "Student-Informal" are found to have significant increase, and "Student-Formal" decreased significantly in the puppetry. The tendency of

Table 1: Definition of codes for utterances in the role-play simulation of microteaching (Fujie,2000)

Utterances	Definition
Teacher-Formal	A teacher's utterance that follows his/her lesson plan or is academic related
Teacher-Informal	A teacher's utterance based on his or her individual experience and reaction to the students
Teacher-Double barreled	A teacher's utterance reflecting the features of both "formal" and "informal" types
Student-Formal	A student's utterance that follows the teacher's instructions or is academic related
Student-Informal	A student's utterance based on his or her individual experience and intention (not academic)
Student-Double barreled	A student's utterance reflecting the features of both "formal" and "informal" types

Table 2: Definition of codes for utterances in the mutual feedback discussions (Rosaen et al., 2008)

Comments	Definition
Focus on Teacher-Management	Managing students' behavior, role in organization for a smooth lesson flow
Focus on Teacher-Instruction	Instructional strategy that facilitates the cognitive and social interaction around the goals of the lesson; focuses on the teacher's role
Focus on Teacher-Double barreled	Reflecting both "Teacher-Management" and "Teacher-Instruction"; focuses on the teacher's role or behavior
Focus on Student-Management	Managing students' behavior, organization for a smooth lesson flow; focuses on the children's behavior or attitudes
Focus on Student-Instruction	Instructional strategy that facilitates the cognitive and social interaction around the goals of the lesson; focuses on how the students responded to the instruction
Focus on Student-Double barreled	Reflecting both "Student-Management" and "Student-Instruction"; focuses on the students' behavior and their response to the instruction
Student Achievement	Preservice teacher indicates attention to student learning and achievement or assesses student learning
Other	Other comments or utterances to maintain the conversation

discourse in "Student-Informal" remains significantly in the 3rd session (self-performance), and "Student-Double barreled" increased significantly, while "Teacher-Informal" and "Teacher-Double barreled" did not decrease significantly but "Teacher-Formal" decreased significantly. This result indicates that puppetry can allow improvisational role-play that includes a variety of voices from pupils, and the effect remains in the role-play in the immediate transfer session in self-performance.

Analysis of the mutual feedback discussions (Table 4) found that perspectives of the participants tended to return to the similar state as the first session, while we can see a slight increase in "Student

Table 3: Total number of categorized sentences in utterances in the discourse in the microteaching role-play

	1st (Self)	2nd (Puppetry)	3rd (Self)
Teacher-Formal	741 (+)	988	817(-)
Teacher-Informal	21 (-)	101 (+)	48
Teacher-Double barreled	45 (-)	182 (+)	108
Student-Formal	450 (+)	436 (-)	456
Student-Informal	98 (-)	219 (+)	193 (+)
Student-Double barreled	26	43 (-)	106 (+)

Note: $\chi^2(10) = 168.712$, $p < .01$, Cramer's $V = .128$. (+)(-) are the results based on the residual analysis ($p < .05$). The group which had data missing was excluded.

Table 4: Total number of categorized sentences in utterances in the discussion

	1st (Self)	2nd (Puppetry)	3rd (Self)
Focus on Teacher-Management	468	331 (-)	420 (+)
Focus on Teacher-Instruction	1131 (+)	755 (-)	1073 (+)
Focus on Teacher-Double barreled	37 (+)	33 (+)	5 (-)
Focus on Student-Management	90 (-)	329 (+)	117 (-)
Focus on Student-Instruction Focus on Student-Double barreled*	304	340 (+)	177 (-)
Student Achievement	28	20	35 (+)

Note: $\chi^2(10) = 368.277$, $p < .01$, Cramer's $V = .180$. (+)(-) are the results based on the residual analysis ($p < .05$).
*Student-Double barreled is merged to Student-Instruction due to few amount of data classified.

Table 5: Total number of categorized essays written after each session

	1st (Self)	2nd (Puppetry)	3rd (Self)
1. Student-centered viewpoint(s) included	31	32	29
2. Images of a variety of students' presence & reactions included	6	23	16

Note: A Chi-Square test was conducted for each item separately because the item 1 can include the item 2 as a theoretical construct. For the item 1, $\chi^2(2) = .182$, *n.s.*; for the item 2, $\chi^2(2) = 9.73$, $p < .01$. Ryan's multiple comparison test on proportions showed a significant difference between the first and the second sessions.

Achievement" in the third session, even though the self-performance role-play in the third session focused on a variety of students' reactions. The analysis of the comprehensive essays (Table 5) shows that there is a significant increase regarding images of a variety of students' presence and reactions, and no significant decrease from the second to the third sessions.

Discussion and implications

This study shows how the use of puppets - as transitional objects that elicit a projection of self (puppeteer) to non-self (puppet) - elicited a variety of informal discourse that is rarely used in self-performance. Those positive effects were also seen in the self-performance when made just after the tangible puppetry. However, the effects were lost in the mutual feedback discussions in the third session. This suggests that the participants could not take in the multiple perspectives of possible pupils in the self-performed role-play very well.

One possible reason is a lack of diverse perspectives in reflection by the participants; they reviewed the role-plays from a full view (video) or a bird-eye's view (animation) every time. Although the participants were able provide mutual feedback with diverse perspectives in the second session, that perspective was lost when reviewing the role-plays using video/animation, and no other interventions were provided in the third session. One promising intervention would be a first-person view in the video or the animation. This will allow the participant to review the role-play from each pupil's perspective, and generate a person-centered learning stance and perspective-taking (Lindgren, 2012). Further research on fostering a much deeper perspective-taking is necessary for improving the tangible puppetry CSCL, in order to ensure proper learning through this method.

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Integrating Social Problem Solving with Programming to Enhance Science Agency Through Creation of Mobile Apps in Middle School

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Abstract: The study investigates the potential of integrating Social Problem Solving with programming to enhance science agency among middle school students. Science agency has been emphasized as an important skill to support an understanding of the real-life applicability of science. Educators find it challenging to develop action-oriented mindset among students. In this paper, we evaluate a curriculum that encourages middle school students to identify problems that interfere with their daily lives and take action by creating mobile apps to resolve them. We analyze reflections of 13 students over a series of twenty-four classes, to create mobile apps using App Inventor. Our findings suggest that enabling students to create socially relevant mobile app can be a precursor to developing an action-oriented mindset.

Keywords: science agency, app inventor, programming in middle school

Introduction

Emphasis has been made by educators to enhance science agency among students to encourage them to become thinkers and doers of science (Basu et al., 2009; Repenning et al., 2015). Initiatives continue to be taken to bring science agency to schools through curricula that support conceptual understanding of science while encouraging students to take action in their community. Most of these initiatives report an enhanced understanding of science, however, the challenge in linking student knowledge with action remains (Buxton, 2010; McNeill & Vaughn, 2012). Scholars continue to express difficulty in enabling students to perceive themselves as agents of change, in other words, capable of causing or preventing issues that affect their environment. Our paper attempts to address the challenge of enhancing student agency by engaging students in a project that provides them with the tools to carry out action at an individual or community level while equipping them with the knowledge of social issues that affect their environment. We use the Social Problem Solving (SPS) framework to help students identify problems that interfere with their daily functioning and App Inventor (AI) to enable them to carry out actions to address these issues. The aim of the paper is to determine the potential of integrating SPS and programming to enhance science agency among middle school students. Specifically, the paper seeks to answer the following research questions 1) Does SPS and programming result in the creation of mobile apps that address relevant social problems? 2) Does SPS and programming aid in the development of science agency among students?

Theoretical framework

The curriculum design for this study is guided by research on science agency (Basu et al., 2009; McNeill & Vaugh, 2010), SPS (Buxton, 2010; Chang, et al., 2004), and use of discourse-intensive pedagogy to introduce computational concepts to students (Grover & Pea, 2013). We used AI to enable students to carry out actions. AI is a blocks-based programming tool, which allows novice programmers to make apps for Android devices (Wolber et al., 2015).

The science agency literature emphasizes creating a "doer" mindset where learners perceive themselves as capable of advancing the world by taking action at an individual or community level (Basu et al., 2009; McNeil & Vaugh, 2012). Research on creating critical science agency with high school students show that they are more likely to take action when (a) issues are personally relevant to them (Skamp et al., 2004); and (b) when conceptual knowledge is accompanied by means for the learner to carry out impactful action (McNeill & Vaughn, 2012). Our curriculum encourages agency by enabling students to create mobile apps that address personally relevant issues.

The SPS literature defines social problems as issues that may interfere with the functioning of individuals in their lives (Chang et al., 2004). SPS is a strategy used to help individuals determine coping strategies for these specific problems (D'Zurilla & Nezu, 1999). These problems may vary in degree of relevance to the learner (i.e., from personal issues to issues in one's community). Programming with AI was selected as the tool in our study to enable students to carry out the action of addressing social problems due to its portability and visual drag & drop programming features. Features such as GPS, location sensor, and barcode reader allow students to develop innovative ways to address context relevant issues (Kumar, 2014). Snapping together graphical blocks of code also makes it easier for novice programmers to emulate the creation of mobile apps in real life (Wolber et al., 2015).

Methods

The curriculum was carried out as a choice class entitled, "App Inventor for Science," at a neighborhood school in West Philadelphia. The curriculum was designed for 7th-grade and ran twice a week for 45 minutes over 12 weeks. The curriculum was delivered in 3 blocks.

Programming with AI: This block aimed to familiarize students with the programming tool. Students were taught to program through a combination of instruction and guided discovery to foster understanding of core programming concepts (Grover & Pea, 2013). Students worked in pairs to solve mini app challenges, where they tinkered with programs that had software bugs (i.e., intentionally placed errors in programming code) to make the apps function, while exploring core programming concepts. This provided room for discourse around student misconceptions of variables, control structures, procedures, and so on. Support in the form of app cards was also provided which was designed to gradually decrease scaffolding as learners become more capable with AI (Repenning et al., 2015).

Selecting social problems: During this block, students were guided through SPS's problem-solution framework (Chang et al., 2004) to identify issues that affected them at personal (e.g., cognitive issues), interpersonal (e.g., issues at home or school), and community levels (e.g., issues in one's neighborhood). Focus was placed on engaging students in conversations that enabled them to critically question how events took place in their communities. After identifying a social problem, students were encouraged to think about ways that an app could resolve the issue.

Creating context relevant apps: In the final block, students created mobile apps for the problem identified. The process began with paper-prototyping, where students selected AI components they wanted to use in their design and sketched their app screens on paper. The prototypes were then reviewed for their feasibility by the instructors and peers. Once reviewed, students began programming the apps. Additional app cards were provided based on each team's needs. Students tested their apps and revised them based on feedback they received from prospective app users. Final apps were presented through poster presentations that included descriptions of the social problem, app solution, and limitations of the app.

Participants and data collection

In this pilot study, we worked with 13 middle school 7th-grade students. Six students were girls and seven were boys. All students had little or no programming experience. Students worked in pairs except for one team where a student had to drop out due to personal reasons. Semi-structured exit interviews that were focused on capturing student learning, served as the primary data source for this study. Student's poster presentations and mobile applications served as secondary sources of data. Responses from interviews were coded by two researchers (first two authors) for two pre-set codes–learner's selection of the social problem, and the development of an agency mindset. Interview questions which probed for descriptions of mobile apps and selection of context relevant issues were triangulated with ratings provided by participants on the general usability of each team's app to determine the relevance of social problems selected by participants (research question 1). In addition, each mobile app was checked for its functionality by the researchers. To analyze the development of an agency mindset among participants (research question 2), participant responses to the following interview question was analyzed, "*Has the way you understand technology or the way you perceive issues that affect people around you changed as a result of participating in this course?* The analysis revealed three emergent themes: (a) Change in student perceptions about being capable of creating technology for social good; (b) Increased awareness of the role one plays in contributing to social issues; and (c) Perceptions of technology as a way to advance one's creativity.

Findings

Artifacts created and social problems selected

Out of 13 students, 11 were able to create fully functioning mobile apps that catered to various social problems in their environment. Students created apps to address issues of nutrition, fitness, energy consumption, recycling pollution, and distraction. Out of seven apps created, six apps directly addressed various issues in the learner's' context and one did not (i.e., *RealCreatureFinder* app). Table 1 shows students' descriptions of their apps along with their environmental usability and motivation behind selecting the issue.

Table 1: Description of student's apps along with team member's motivation behind selecting the social issue

(Title) Issue	App Solution	Motivation
(Weightless) Students are bullied due to their weight and appearance.	The app provides a diet and workout plan along with videos of workout sessions based on the selection of time period within which he/she would like to see the desired months.	"*Well, I know a lot of people who would like to loose weight and who get made of and have a lot of anxiety dieting and stuff because of their weight and their appearance because people get bullied on how, how fat they are or how skinny they are in school.*"
(PAS) Students aren't aware of the food being served at school and waste food when they pack food from home.	The app allows users to access and view the breakfast and lunch menu served at school and displays the nutritional value of selected items.	*"Some kids may like some lunches and not like other lunches and they may want to save some food by not bringing lunch everyday to school if they know the lunch being served that day.*"
(No time to play) Students are easily distracted when they log in to complete their home assignments.	Users can log into any online resource assigned by school to complete their assignments for a set time. Once the time is completed, the app makes a celebratory noise and displays, "You have done it!"	"*Usually when I do my homework I usually get distracted so most of the time I never get my homework done on time. So I just thought making an app would help me, help other people like me who get distracted when doing homework.*"
(Energy) Unmonitored usage of appliances results in energy wastage.	The user can record the time spent on various appliances and generate an electricity bill based on usage.	"*A lot of people wanted to do air pollution and water pollution and stuff like that. But not a lot of people look at electricity and say that is a problem.*"
(Pollution) Children aren't aware of the harmful effects of pollution.	The provides users with animated videos that explain the long-term and short-term dangers of using pollutants.	"*We can always see trash when there is a trash can like right next to it. People are the main source of pollution and I think if you...raise awareness around it then people will try to stop it more."*
(RealCreatureFinder) There is a lack of creativity among adults and teens.	The app allows users to summon various mythical creatures by using spells. Each of the characters have separate screens with detailed information about them.	"*We have an obsession with unicorns and other mythical creatures so we decided to make an app about it.*"
(TrashBro) Students have only limited knowledge about recycling.	The app provides information on various kinds of trash. It has a game that sorts' random trash correctly into 'recycle', 'compost', and 'trash' bins.	"*I have trouble recycling, like at home, when I use a tissue I throw it into the recycling, but I found out it can't go into recycling. This way I learned more about it which will make the environment cleaner.*"

The degree of usability varied with the apps. Among the apps created, No time to play and PAS resonated most highly with participants in terms of usability. Out of 13 students, seven stated that they would use the No time to play app as it helped them deal with the issue of getting distracted while doing assignments online. Six students stated that they were more likely to use PAS because the app provided a way for them to track the lunch being served at school, which helped them decide whether or not to bring lunch from home. About the apps that dealt with social problems at a community level (i.e., the Energy app and Pollution apps), five students stated that although they found the apps to be a good solution to relevant issues such as energy wastage and recycling, they did not see themselves using the app. Eleven students rated RealCreatureFinder as a non-useful app. The reasons included the impracticality of the app, as 'those creatures don't exist' (seven out of eleven students) and the inefficiency of the app in addressing the 'issue of enhancing imagination' (four out of eleven students). The analysis of post interviews indicated the significant role self-expression played in identifying app ideas. Eleven students said that they were motivated to pick a social problem that they or their friends had experienced at home or their school. While two students mentioned that they wanted to create an app that aligned more with their interests with less focus on addressing a social problem. The developers of the *RealCreatureFinder* app decided to pursue the topic that appealed more to their personal interest when a conflict arose between picking a relevant social problem over a topic that was more interesting to them (i.e., unicorns).

Development of an agency mindset: Perceiving self as a "doer of science"

The majority of participants were able to create a link between using the knowledge of programming and taking action to address social issues. Ten out of 13 students mentioned that learning how to program mobile apps helped them see how they were capable of creating technology that was useful to their environment while two motioned that it helped them to think of ways to advance their creativity. The developer of the Energy app commented, "Before this class, I was just seeing technology as a place where one could do many things but when I came to this class I learned what I can actually do with technology to better the world." A developer of the TrashBro app stated, "In science class, we learn about science and technology. We have brief descriptions of pollution and atoms and less of technology. In this class I see technology enables us to interact with science and now I can make my own app." The remaining three students mentioned that the class helped them think critically about how their actions added to some of the issues they selected in class. A developer of the Pollution app commented, "I feel like I shouldn't waste stuff more, before, like when I go for dinner, because I spend all of my time in that room and then when my mom calls me down for dinner I used to just leave my light on and computer till I come back, but then I turn it off so that I don't waste power now." Overall, the analyses of student experiences show that while a majority of participants were able to critically think of ways in which they could create technology for social good, some were able to reflect on how their daily actions might be altered to address social problems.

Discussion

The study analyzed the potential for integrating the knowledge of programming with SPS to enhance the science agency among middle school students. Our findings suggest that enabling students to create socially relevant mobile applications can be a precursor to developing an action-oriented mindset. Majority of students reported enhanced awareness in terms of being capable of developing technology for social good as a result of engaging in the curriculum. These findings suggest a way to address the challenge of creating a link between conceptual knowledge of social issues and taking action at a community or individual level among learners (Buxton, 2010; McNeill & Vaughn, 2012). The reported changes in student perception of technology being used for social good also suggests a powerful way to introduce programming to promote computational perspectives – perceiving programming as a tool to create artifacts of value to oneself and others among middle school learners (Brennan & Resnick, 2012). Studies have shown that the extent to which students perceive an issue to be personally relevant influences their decision to take an action to impact an issue (Skamp et al., 2004). The majority of students were not only able to successfully select issues that were personally relevant by using the SPS framework but were also able to create apps that appealed to the interest of other users. However, our findings suggest that if a conflict of interest rises between personal interests and picking a social problem that may not be personally relevant, the learner is less likely to engage in taking action.

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Symbiotic Learning Partnerships in Youth Action Sports

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Abstract: Reporting on an ethnographic study of youth media production at an action sports camp, this paper describes the symbiotic learning partnerships formed between teen skateboarders and teen videographers necessary to collaboratively demonstrate mastery of both tricks and video capture/editing. Symbiotic learning partnerships emerge when partners are, as one participant says, vibing with one another: when they are deeply invested in the production of a collaborative media artifact that they will jointly distribute across social media. When vibing with one another, skaters and videographers fall into collaborative, rhythmic cycles. This collaborative mastery is illustrated specifically through a focus on the cycles of reflection and nurture that skaters and videographers enter into when honing their respective crafts. This paper advances understanding of youth digital media production in the rich, yet understudied, action sports community, drawing out potential implications for the design of digital media learning settings, broadly.

Purpose

Action sports—skateboarding, BMX, snowboarding, etc.—have a long, intimate history, with digital media production (Hutchins, Meese, & Podkalicka, 2015; Hutchins, 2016). Increasingly, digital technologies and networks make both the production and dissemination of authentic videos, photos, and stories possible (Thorpe, 2014, p 70). Recording, editing, and publishing "one's peers 'in-action,'" Thorpe (2014) writes, "is part of the everyday experiences of many groups of committed action sports enthusiasts" (p. 70). Still, as youth digital media production research is nascent, much of the literature focuses on individual efforts, especially in out-of-school settings, as those efforts propel youth down interest-driven pathways (Ito et al., 2013). Through an ethnographic study of youth media production in action sports, this paper analyzes *the symbiotic partnerships* formed between teen skateboarders and videographers necessary to collaboratively demonstrate mastery of both tricks and video capture/editing. This collaborative mastery is illustrated through a focus on the *cycles of reflection and nurture* that skaters and videographers enter into when honing their respective crafts. In the end, this paper advances understanding of youth digital media production in the rich, yet understudied, action sports community, drawing out potential implications for the design of digital media learning settings that promote equal educational opportunity for youth, as per the conference theme, through an overt focus on symbiotic learning partnerships.

Theoretical orientation

The guiding focus on symbiotic learning partnerships is informed by the interdisciplinary new mobilities paradigm (Sheller & Urry, 2007). The new mobilities paradigm offers an entry point to consider the partnership between learning and the moving, sensing body. This entails attention to the corporeal engagement with other bodies and technologies, practices of movement (i.e. biking, skating), as well as events of movement (i.e. commuting, sitting in traffic)

Within the new mobilities paradigm, however, there is an ongoing interest in passengering (Adey, 2012). Etymologically, the term passenger dates back to the 15th and 16th centuries where it marked both the person who travelled, as well as the person, or thing, that enabled the travelling. Within cultural geography, a number of studies have investigated the experience of the passenger (Laurier et al., 2008; Bissell, 2010; Adey et al., 2012). These studies note that the "bodily experience of the passenger…is not simply one in which [the body] is an anonymized parcel of flesh...shunted from place to place just like other goods" (Thrift, 2004, p 266). Rather, for one to become a passenger, one is always in the emergent process of "being" or "becoming with" (Bissell, 2010, p. 270). In fact to talk of "'fellow passengers might gesture to the fraternity of togetherness that emerges through moving with others" (Adey et al., 2012, p. 171). Passengers are always "becoming with" someone or something—other riders, other drivers, other things.

Overall, both the new mobilities paradigm, and the embedded theories of passengering, enable me to consider the ways in which skaters and videographers "become with" one another through their symbiotic partnership during the experience of digital media production.

Method

The study of symbiotic learning partnerships was situated at a 12-week long summer action sports camp (hereafter Camp) located in the Northeastern United States. Camp offers opportunities for youth—and adults—to hone skills related to action sports, including skateboarding, BMX, parkour, tumbling, digital media, and more. Campers choose one focal track for the week (i.e. Skateboarding, digital media), learning alongside peers, teen interns, instructors, and professionals.

My analytical interest was drawn to the collaborative partnerships that emerged between photographers/videographers and athletes (i.e. skaters, bikers). This paper hones specifically on the symbiotic learning partnerships that emerged between a camper-turned digital media intern named Erich and a skateboarder named Markus. Erich is a 17-year old videographer. Having attended Camp for two years, Erich earned his role as intern by producing a video "edit" that was deemed high quality by his instructors. Because of his success, Erich was invited back to Camp as an intern, producing video footage and edits for Camp that would be used for marketing and social media purposes. Similarly, Markus, an accomplished 16-year old skater, impressed instructors in previous years, and was thus invited to attend Camp, acting as an informal instructor throughout the summer for younger campers. Prior to the summer, Erich and Markus did not know one another. Over time, however, they developed a solid partnership that shaped their symbiotic learning together throughout the summer as Erich repeatedly shot video of Markus while Markus skated.

I observed Erich and Markus shoot/skate together for over ten hours throughout the months of June and July—each collaborative session taking roughly an hour as Markus sought to land a specific trick or "line," a pre-planned string of numerous tricks, and Erich sought to capture the line accurately and artistically. Typically, tricks and lines take about one hour to film. Rarely, does the skater land a trick or line on the first try. Rather, there are many starts and stops, falls and scrapes, all of which offer numerous opportunities for the skater and videographer to communicate as well as to refine their respective approaches.

Data collection followed qualitative methods of observation, field notes, and semi-structured interviews. Oftentimes, I set up my video camera behind Erich, capturing him capturing Markus. In-between tricks, I would talk with Erich and Markus, learning more about their respective techniques, their goals for the shot or trick, or about their interactions with one another. I frequently spoke with Erich, Markus, and others about my observations and these conversations served as member checks.

Analytically, I employed the constant comparative method, beginning with open coding at the outset of my data collection, before subsequently refining codes and constructing/refining categories. Importantly, these categories were iteratively produced, and dependent upon my full immersion at Camp: hanging out in the staff room together, going on golf cart rides to ramps and skateparks together, watching skate videos together, and more.

Findings

Symbiotic learning within reflective and nurturing cycles

In action sports, like skateboarding, symbiotic learning partnerships emerges as skaters and videographers "become with" (Bissell, 2010) one another. Skaters and videographers, enter into this "fraternity of togetherness" (Adey, 2012) as they each seek to hone their respective skill-sets: Videographers continuously alter their technique in order to capture the best possible image; Skaters continuously alter their technique in order to help produce the best possible image. As one skater put it:

> If you're not down with the guy you're filming with; if you're not vibing with the guy you're filming with; you don't vibe with the guys you're shooting photos with; you're not gonna get the trick…It has to be a symbiotic partnership in the long run. Like, I'm producing for you, but you help me with everything that goes on in that situation. It has to be symbiosis at the end of the day.

In the following, I explore what it means to "vibe with someone you're filming with" through an analysis of the symbiotic partnership between Erich and Markus. Specifically, I explore two facets of this "symbiosis." First, I analyze the reflective cycles that they enter into with one another. Then, I analyze the ways in which videographers nurture both the skater and the trick within those reflective cycles.

Reflective cycles in symbiotic partnerships

Figure one depicts a common sequence in symbiotic partnerships.

Figure 1. Stages of reflective cycle, including failed attempt at trick (top) and reflection (bottom).

Erich halts filming as Markus, having failed at his trick (an alley-oop back lip) on the vert ramp, lays sprawled on the ground. Quickly, though, Markus bounces back up and walks toward Erich. Together, Markus and Erich then enter into a reflective cycle by watching and discussing approximately 15 seconds of film together, including Markus dropping in and onto the ramp, his first attempt at the trick, and his subsequent fall. They will enter into this cycle nearly 15 times throughout their hour-long skate sessions. A regular conversation such as the following ensues, as Erich and Markus review the clip:

E: What happened there?

M: I tried to pull it around, but it didn't quite work out.

E: Ah, yeah, you didn't get [the board] far enough. I mean, I assume you're gonna land right in front of me right…

M: Yeah, sorry about that.

E: It's all good…

Erich's initial question—"What happened there?"—invites Markus both to critique his now-failed trick, as well as to approach Erich to discuss it. They enter into a reflective cycle. Markus upon watching and viewing his error, recognizes that he didn't turn his board far enough as he was spinning in the air. Erich, while helping Markus think through his own trick, also reflects on his own practice as he asks Markus to clarify where he is going to land. In doing so, Erich seeks to anticipate where Markus will land so he can ensure he has directed the camera to the right place at the right moment. Thus, the reflective cycle serves both skater and videographer as they each seek to hone their respective craft.

Nurturing cycles in symbiotic partnerships

The reflective cycles also open up opportunities for the videographer to nurture the athlete towards success. Skater-videographer partnerships, then, become relatively intimate, especially as the skater struggles to overcome challenges. "Knowing how to approach people," Erich notes, "is important, especially when they're mad." Reflective cycles, then, become moments to offer support and guidance for the skater. For example, as Markus walked over to talk with Erich after one failed trick, Erich worked to build up Markus' dwindling enthusiasm, sensing his frustrations: "This line is easy for you, man. It's like that alleyoop lipslide, like you had the other time. I think it's sick, though, like back to back (from last week)."

Furthermore, in "becoming with" one another, skaters and videographers must keep lines of communication open at all times. One skater, for instance, noted that he could no longer shoot photos with a specific videographer "because he wouldn't talk to me when I was mad." Beyond discourse, however, embodied gestures of support also serve their purpose. When not verbally supporting Markus, for instance, Erich regularly put a fist out for Markus to fist-bump (Figure 2). The fist-bump, then, both closed off the conversation while simultaneously urging Markus toward success in his next attempt at the trick.


Figure 2. Fist bump closing off reflective and nurturing cycle.

Overall, it's a "collaborative process," one photographer said, in that the skater and photographer/videographer both want the best for the other. By entering into both reflective and nurturing cycles with one another, then, videographers and skaters generate feelings of camaraderie—of being in this moment, doing this trick, at this time, together, until fully satisfied with their respective outcomes.

Significance

To date, digital media production, especially in dynamic informal, out-of-school settings, has predominately underscored individual efforts (Nacu et al., 2016; Halverson, 2013). While collaboration is certainly built into regular activities, research has not yet explored long-term learning trajectories evidenced in the symbiotic partnerships that dominant action sports, of which Erich and Markus are a micro-sample. Moreover, designed learning environments often further facilitate individual "pathways" for learning. Such designs, then, are potentially myopic as they re-instantiate individualistic "imagined geographies of learning" (Leander et al., 2010) that operate in traditional school settings. The action sports community, then, and the powerful symbiotic partnerships that encourage both reflection and nurturing therein, offer new possibilities to continue to re-imagine learning settings—both in and out of school—that could potentially promote equal educational opportunities for all youth.

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Showing *and* Telling: Response Dynamics in an Online Community of Makers

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Abstract: Online communities are an important learning resource, especially for learners in Makers, Making, and 3D printing. In this study, we examine one online Maker community called SoliForum to better understand how an emphasis on producing physical objects shapes online interaction; specifically, what kinds of messages elicit useful responses for those seeking help. We found that compared to text-only posts those with media elements had a higher response rate and more resolved problems. Based on our analysis we attribute this to the more descriptive and explanatory power of multimedia and its ability to better represent physical objects. The findings suggest that guidance for crafting messages using multimedia can lead to more equitable participation and learning in online Maker communities.

Introduction

Prior work on the educational implications of Maker Movement (Halverson & Sheridan, 2014) has focused primarily on informal learning in physical spaces or Makerspaces (Forest et al. 2015). A crucial element that is missing is the role of online communities in in supporting informal learning related to Making. The Maker Movement resides largely in the digital ecosystem and this self-emerging, cyber-physical, and sociotechnical system is one of the primary innovations of the Maker Movement (Litts et al. 2016; Martin, 2015; Rafalow, 2016). Writing about the potential impact of the Maker Movement on education, Martin (2015) outlined three critical elements to consider: 1) availability and advances in digital tools, including rapid prototyping tools and low-cost microcontroller platforms, that characterize many making projects, 2) community infrastructure, including online resources and in-person spaces and events, and 3) the maker mindset, values, beliefs, and dispositions that are commonplace within the community. He argues that integration of new tools into the practices of Makers is relatively easy because in the online community "people can read manuals and tutorials, watch videos, converse through forums, and share code (Martin, 2015, p. 34)." The value of the community also extends the role of mentors who provide the expertise required for problem solving and also serve as role models to youth. Martin (2015) recommends that given the role of community-driven processes in learning and identity development there should be more research on "online learning communities (p. 36)."

Online communities as a learning resource

With increase in online activity, online discussion forums have become increasingly popular for problem-solving and help-seeking (Teo & Johri, 2014). Research shows that online forums are also robust platforms for learning as they evolve over time and become a rich source of information for participants due to the interpersonal exchange. For instance, van De Sande (2011) examined an online help forum for mathematics and found that learners receive general forms of help that orient the learners towards resolving homework challenges. Similar findings are echoed by Puustinen, Bernicot, Volckaert-Legrier & Baker (2015) in their study of help-seeking exchanges in homework help forums. These forums are not only helpful, they are also highly efficient. For instance, Teo & Johri (2014) found that more than 88% of posed questions in a Java forum receive at least one answer and answers were typically of high quality. Although prior work shows that online discussion forums have emerged as a popular source for problem-solving help and potentially for learning, online forums related to Maker/Making have to rely significantly on non-text based interaction, such as images and videos. What effect does this have on interaction among users if any? Prior work has examined use of text across a range of online communities and has looked at different forms of text-based information (e.g. Velasquez, Fields, Olsen, et al., 2014), but has not looked at response dynamics in a mixed-media online community environment, which is the goal of this study.

Case study of SoliForum

SoliForum is a popular 3D-prining online community that supported Solidoodle, a 3D printer launched in September 2011. Solidoodle 3D printers use digital files supplied by the user to create physical plastic parts. Although the company went out of operation in 2016, SoliForum was and remains an active community with in-depth discussions related to 3D printing. For this study, we analyzed one forum related to Solidoodle within SoliForum "Help/Repair/Maintenance", which we are calling SoliForum-Help. This forum focuses specifically on help-seeking and sharing of 3D objects making problems. The forum contains 19,850 posts by 1179 community users across 2265 threads spread over 4 years (08/10/2012-09/10/2016). Similar to other online communities, the majority of users had 10 or fewer posts on SoliForum-Help but the response rate for questions was 93.8%. Of the total users, 4 members had more than 500 posts each whereas 29 community members had between 100-500 posts. Discussion forums differ in their design features and in SoliForum posts are chronologically ordered within a thread. There is no affordance for responding to a specific message within the thread and any new response just goes at the bottom of the thread. There is also no rating or vote for the posts. However, it allows users to incorporate different informational representations to convey a message, such as images, links, videos and attachments.

Response comparison

The data selected for this analysis are threads that received at least one response and fall into one of the groups: *group1-plain*, which include threads using plain text-only in the original post of the thread, and *group2-multimedia*, which include threads containing images, videos, or attachments in the original post of the thread. Table 1 summarizes the number of threads for each group and the response time to get the first response, response rate, which is the percentage of the threads in this group that got at least one response and the average number of replies in each group.

Table 1: Response time, rate, and average number of replies (multimedia vs. plain) groups

	Response time	**Response Rate**	**Average (#replies)**
Plain Group (N=714)	44 min 12 sec	93.3%	8 (SD = 10)
Multimedia Group (N=622)	48 min 5 sec	95.8%	9 (SD= 11)
p-value (alpha = 0.1)	p= 0.4981	**p= 0.02144**	**p= 0.04203**

The result of t-test statistics shows that the average number of replies and the response rate is significantly higher (90% confidence level) in the multimedia group. Although response time is faster in plain group, the difference in the response time between the two groups is not statistically significant at (alpha=0.1). Breaking the multimedia down into images, videos, and attachments (att), we can see a finer grain of the responses in the different data representation use; videos and images garnering more than the average response (Figure 1).

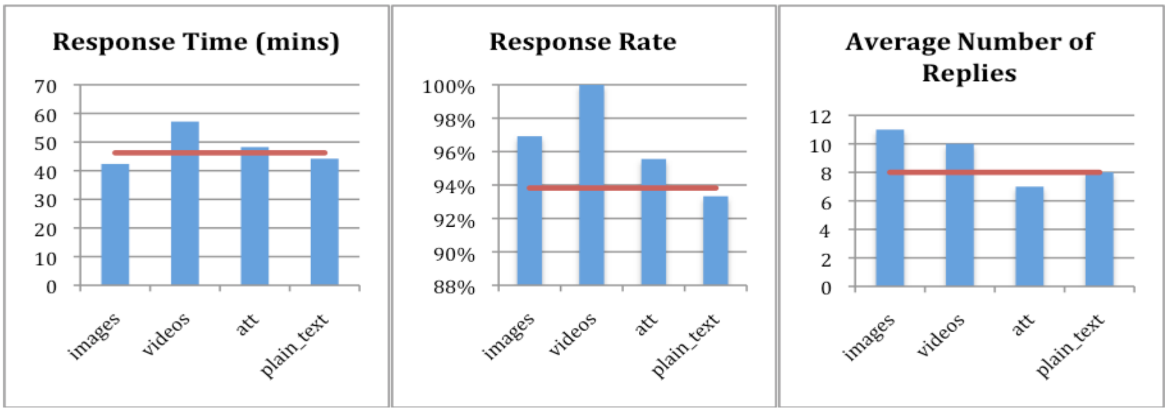


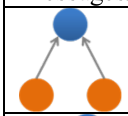
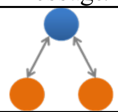
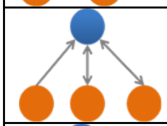
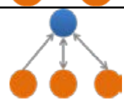
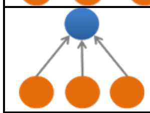
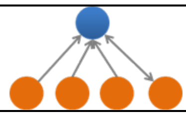
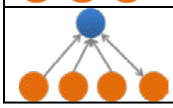
Figure 1. Response time, rate, and average replies in regard to multimedia element used (images, videos, and attachments) and plain text.

Identification of frequent communication patterns within a thread

To further understand the communication patterns within the forum, a network graph for each thread was constructed to analyze the communication among the participants (Teo, Johri & Mitra, 2013). Since SoliForum-Help does not have a "reply-to" feature to respond to a specific message within a thread, to determine the relationship between poster and responders the following assumptions have been made: (1) if it is a new poster and there are no quotes, it is a reply to the original poster; (2) if it is not the first post by the poster and post does not have quotes, it is a reply to the previous poster in the thread; and (3) if the post has a quote, the response is to the quoted member.

To identify the frequent sub-graphs in a thread a data mining algorithm *gSpan* was applied (Yan & Han, 2002). In this analysis, a sub-graph is considered frequent if it occurs in at least 25% of the discussion threads. To identify a frequent pattern across two groups, they should have the same length of conversation (number of replies) otherwise the algorithm will not detect patterns with higher degree (number of participants) because such a pattern will not exist in the shorter thread. After applying the algorithm and looking at the results for different conversation lengths, we decided to proceed with lengths 8 and 10 as a sample for our analysis because threads with fewer than eight messages did not show any meaningful frequent patterns and we did not have enough threads with more than 10 messages to have a representative sample of analysis. Table 2 presents the super frequent communication patterns among the participants in a discussion thread. All subsets of the super communication pattern are also frequent but not shown here for clarity. If a frequent communication pattern between participants occurs in one group but not the other, the latter is assigned (NF: Not Frequent), while the former is assigned the percentage of occurrence in the respective group. In Table 2 the blue circles represent the help-seeker who posted the original post in a thread while the orange, second level, circles represent help-givers. It can be observed in Table 2 that threads in the plain group have more unidirectional interaction. In contrast, multimedia group especially with length 8 tends to have more connected bidirectional relations within a thread. There were some interaction among help-givers but they were not frequent to happen more than 25% of the time.

Table 2: Frequent communication patterns (occurrence percentage) among participants within a thread

Sub-graph	**Plain Group**	**Multimedia Group**	**Sub-graph**	**Plain Group**	**Multimedia Group**
Messages/Thread (10)	N=18	N=26	Message/Thread (8)	N=32	N=32
	0.67	0.38		0.28	0.56
	0.33	0.31		NF	0.34
	0.56	NF		0.25	NF
	0.44	NF			

To supplement the findings of the sub-group analysis we further conducted a quantitative analysis of (1) help-seeking frequency and the number of help-givers participating in a thread for a sample that has 8 replies, and (2) text length for the two groups. Table 3 shows that the help-seeker (original poster) average participation within a thread in multimedia group is significantly higher than their counterpart group ($p=0.047<alpha=0.1$) possibly indicating that they are more engaged in the problem-solving.

Table 3: Comparison of help-seekers and help-givers across multimedia vs. plain groups (within a thread)

	Help-seeker participation		**Unique help-giver participation**	
	Mean	Standard Deviation	Mean	Standard Deviation
Plain Group	3.688	1.120	3.75	1.524
Multimedia Group	4.219	1.362	3.406	1.876
p-value	**p= 0.04652**		p= 0.21101	

Text length for both groups was analyzed in (Table 4) to see if using multimedia substitutes the text. An average word count shows a significant difference, hence median was also computed to account for any outliers and the difference is still significant. This suggests that forum users not only visually displayed the solution but also explained the steps textually.

Table 4: Length of text comparison for multimedia and plain groups

	Number of Threads	Word Count		
		Average	Median	SD
Plain Group	765	97.84	85	62.06
Multimedia Group	649	173.756	130	234.96

The presence of a back-and-forth exchange begs the question – is there ambiguity when the multimedia is used in the original post of a thread? To answer this question we did a qualitative analysis and read through a sample of 64 threads, 32 from each the plain and multimedia group, each with length 8 to examine the nature of interaction within the thread posts. There was no confusion observed when more complex informational representation (multimedia group) was used. In fact, about 21% of the plain group threads were asked or had provided a richer informational representation in the course of the discussion. The reason for this could be that multimedia group posters had specific questions and were eager to get the answer with more help-seeker engagement, while in the plain group, members asked primarily for suggestions (they had a breadth with higher number of respondents but less of help-seeker engagement). Furthermore, problems posed in multimedia group were more likely to be resolved (56.25%) as compared to the plain text group (where only 37.5% of problems were resolved). There was no definite marker of an issue being resolved and a thread was considered solved if the original poster acknowledged the issue is resolved. It is quite possible that the rate was higher.

Conclusion
The findings from our study illustrate that in this Maker-related community the use of photos, videos, and other media artifacts improved the response rate for those seeking help and the responses they received were more thorough and richer in information. Help-givers preferred the information they received from help-seekers to be in a form that was easy to understand. Help-seekers were also more engaged in the problem-solving process when they used more media. The primary limitations of this research are that the study is based on a single setting and the sample size used for comparison is relatively small.

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Instant Sharing Makes Task More Engaging in Computer Aided Classroom

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Abstract: With the advent of networked computers sharing of information and artifacts have become very convenient. From online multi-player games to social networking sites, instant sharing has become the norm of the day. Educational tools are trying to harness sharing as a potential tool to engage students in learning processes. But, does sharing lead to an improvement in academic performance? The present study investigates the role of instant sharing in the context of learning in a classroom setting. Two groups of students, from a suburban school in Mumbai, India, played an arithmetic game over a period of 7-8 months. The experimental group played on a platform that supported instant sharing, while the platform for the control group was standalone. All other aspects of both platforms were same. Analysis of process data of the two groups reveals that instant sharing increased engagement with the game. Students from control group lost interest in the game after some days, while experimental group students remained active on it till the end of the four-month period.

Introduction

Learning activities can broadly be thought about as self-learning, group mediated learning or learning by mentorship. Computer-based self-learning activities through standalone applications impose no time and location restrictions on the user. With advances in ICT (Information and Communication Technology), robust shared platforms are now possible. Networked computers have opened up many new possibilities for group activities. Learners no longer require to be in the same physical space to be able to participate in a group activity. Synchronous and asynchronous sharing makes varied types of interactions possible among peers in a group.

Measuring learning in computer-supported environments is a difficult task (Stahl, Koschmann, & Suthers, 2006). In such environments engagement has been used by researchers as one of the yardsticks for measuring learning. Engagement is considered as a good predictor of academic performance (Wise, Skues, & Williams, 2011). Student engagement is not an easy concept to define, there is a lot of literature which tries to establish its definition. For this paper, we borrow Wise et al., (2011)'s idea of student engagement. According to them, student engagement has three aspects: affective, behavioral and cognitive. Wise et al., (2011) also talk about the affective aspect of engagement as being a gateway to the behavioral and cognitive aspects of engagement. In this paper, we are only focusing on the behavioral aspect.

Researchers and educators are working with computer applications having sharing (synchronous or asynchronous) features and testing them through the lens of engagement. Some have found that sharing helps in learning (Shaikh, Nagarjuna, & Chandrasekharan, 2013; Junco, Heiberger, & Loken, 2011) whereas others say sharing increases social engagement but does not guarantee learning (Wise et al., 2011). The contradicting results of these studies indicate a lack of clear understanding of the interplay between sharing, engagement, and learning. The question which needs to be answered is: What does sharing add to (or subtract from) a learning activity?

There aren't many studies which look at the changes in learning processes when sharing is involved, especially for primary students. Most of the existing literature focus on the effect of sharing in distance learning which introduces many variables which are difficult to control (Kreijns, Kirschner, & Jochems, 2003). The present study is situated in a classroom space with synchronous sharing for the experimental group with tight control over variables. The study tries to analyze the effect of instant sharing on learning strategies.

Design features

Many computer applications today allow sharing of a screen space among multiple users where posts/entries by one user are instantly available to all the other users. From the perspective of distributed cognition framework, the shared screen is an extension of the user's memory to which others have access, which we term as "shared mental space". In the present study, instant sharing was instantiated by the use of shared screen (or "shared mental space") among multiple users.

OLPC (One Laptop Per Child) laptops called XOs with SLP (Sugar Learning Platform) operating system were used in this study. Papert's (1980) constructionist theory had a big influence on the laptop's design (hardware and software) and the theoretical framework being used for the present study. Every application in OLPC laptops is called "Activity". A simple arithmetic task was implemented as two activities, one with the feature of screen sharing across all the participants while the other one being standalone. Both the activities were designed to help the student learn arithmetic skills.

44 students (16 girls and 28 boys) of 4th grade from a single classroom in a local Municipal Corporation school in suburban Mumbai were selected for the study. The medium of instruction was Marathi (vernacular language) and one female teacher taught all the subjects. The students were divided into two groups, each consisting of 22 students. Researcher played the role of participant observer. Each group interacted with computers on alternate days for one hour. The same researcher conducted the one-hour sessions for both groups.

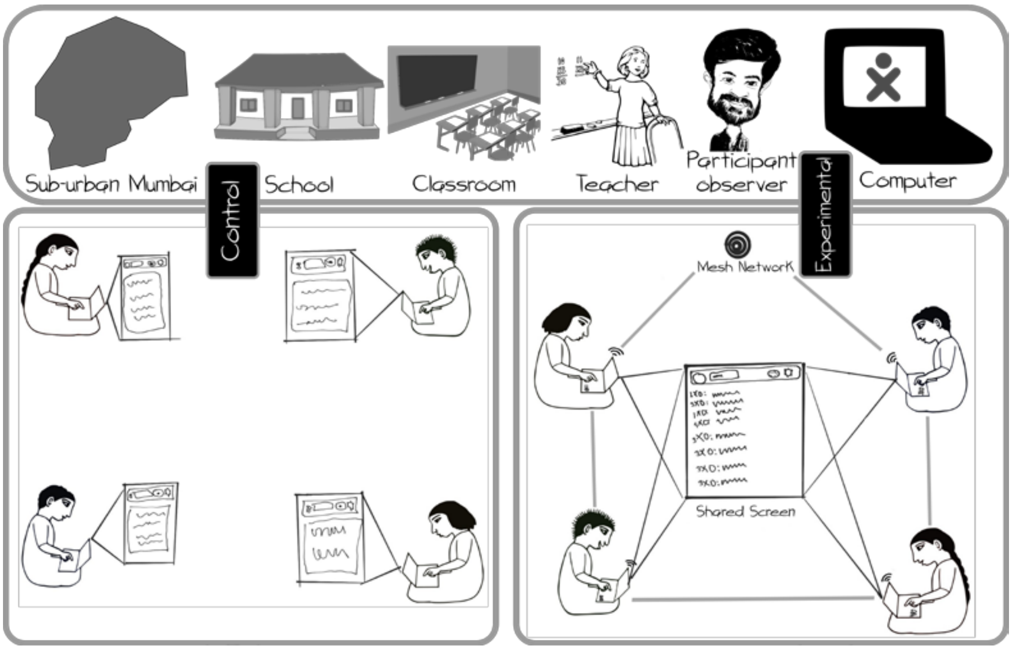

Figure 1. Experimental Setup.

Figure 1 shows the experimental setup followed for the study. The two groups were equivalent as based on an arithmetic test. Additionally, students of both the groups belonged to the same locality, studied in the same classroom, were taught all the subjects by the same teacher, used same laptops. While the experimental group played with/against their peers, the control group played against the computer. Activity for the control group was called Chat Studio Self (CS-Self) activity and activity for the experimental group was called Chat Studio Group (CS-Group) activity. The facilitator did not force the students to work on the activity designed for the experiment. The students were free to explore other applications present on the computer.

Data collection

The study was carried out over a period of 64 working days spanning over a period of 7-8 months. Data collected during the period included computer logs, computer meta-data, audio recordings of classroom transactions, video recording of few sessions, field notes taken by the researcher, students and teacher interviews and the arithmetic test performance before and after the study.

Results and discussion

The collected data are currently being analyzed, we are only presenting the analysis of computer logs and meta-data. The operational definition of engagement used in this paper (as we are only focusing on the behavioral aspect of engagement currently) is number of sessions of an activity. A session is a game completed by a student. Preliminary analysis shows different engagement patterns (number of sessions per day) for the experimental and control groups.

Considering the number of sessions (1 session = 1 game) of the designed activities (CS-Self and CS-Group), experimental group (n = 649) had played more number of sessions than the control group (n = 252). Considering the number of sessions of activities other than the designed ones (CS-Self and CS-Group), control group (n=792) had more sessions of such activities than experimental (n=540) group. The sessions of the designed activity (CS-Self and CS-Group) will now on be referred to focused sessions, while the sessions of activity other than the designed activity will be referred to as exploratory sessions.

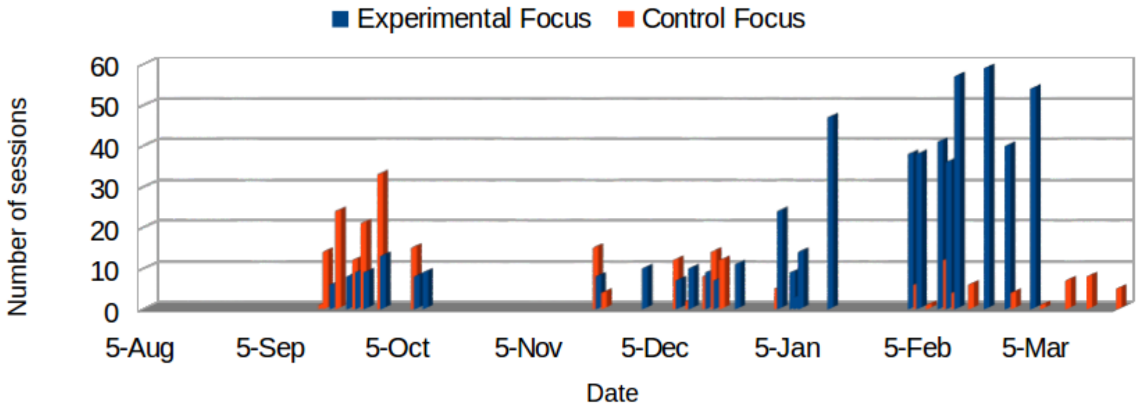

Figure 2. Number of focused sessions vs. time.

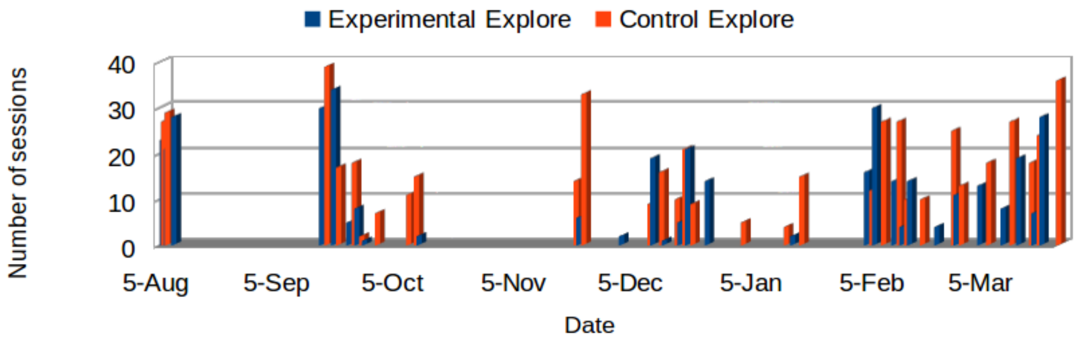

Figure 3. Number of exploratory sessions vs. time.

A deeper look at computer logs and meta-data showed that not every student from each group played the designed activities. 5 to 7 students from each group had only 1 or 2 focused sessions. Removing the data of such students from the analysis, top 15 students out of the total 22 students from each group were selected. Figure 2 and 3 show data of these top 15 students of both groups. Figure 2, the number of focused sessions plotted against time, shows that while the number of focused sessions for control group (CS-Self) is decreasing with time, it is increasing for the experimental group (CS-Group). A possible explanation could be the presence of instant sharing in the experimental group considering that all other known variables are controlled. Figure 3, shows that the control group was more consistent in exploring compared to the experimental group.

Both the groups showed significant improvement in performance on an arithmetic test (p=0.009 for the control group and p=0.068 for the experimental group). The process data offers some patterns to understand what lead to the apparent learning in both groups. A fairly strong correlation (r=0.67042) was found between improvement in arithmetic score and number of sessions of focused activity (CS-Group) for the experimental group, meaning students who played more session learned more. The same correlation (r=0.0260) does not hold for the control group.

With some confidence, it can be said that the experimental group students have learned arithmetic by playing focused activity but we cannot draw the similar conclusion for the control group. Students from the control group have learned arithmetic operations but the source is not focused activity (CS-Self) but something else. It can be exploratory sessions (many non-focused applications on the computer had some element of arithmetic) or it could be something extrinsic to the study.

A major chunk of the data (computer logs, meta-data, focused group interviews, audio and video recordings and field notes) is yet to be analyzed. A definitive conclusion cannot be made at this point, but the patterns emerging from data suggests that availability of instant sharing (shared mental space) in an activity (application) increases the probability of student engaging with that activity for longer time. In this study, the engagement with the arithmetic task was sustained for months in the experimental group.

Once students are engaged with an activity their chances of learning does increase but social engagement does not necessarily guarantee learning (Wise, Skues, & Williams, 2011). In the present case, it appears that student engagement has lead to learning. It seems that sharing emerges as a design feature for education tools to increase engagement and learning. The improvement in the performance of the control and experimental group in the arithmetic test suggests that there can be multiple routes to learning. As the data suggests, the experimental group was engaged with the designed task which could have resulted in learning while the exploratory nature of the control group sessions could have lead to learning in the control group. The present correlation data does not necessarily mean a causal connection. Further quantitative and qualitative analysis of data will bring more clarity, which could eventually bolster or enervate the claim.

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The Digital Use Divide and Knowledge Building

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Abstract: This paper delves into the digital divide challenge through an interaction analysis of educational partners engaged in co-designing, sustaining, and scaling classroom-based innovation using collaborative platforms in rural settings. The innovation is analyzed by referring to an emerging multilevel multiscale model, with emphasis on the five dimensions of Dede's conceptual framework (Depth, Sustainability, Spread, Shift [in Ownership], and Evolution, 2006). Organizational structures, interaction processes put in place and the technology in use during the Remote Networked School (RNS) initiative are identified.

Keywords: Innovation, scalability, collaborative technologies

Introduction and background

At the onset of the Remote Networked School (RNS) initiative in the Province of Quebec, Canada, the target was to temper the closing of small rural schools, based on the assumption that Internet-enabled activities would enhance the learning environment (equity of access and quality of education). Online courses not being an option, this constraint became an opportunity for suggesting the use of the computer for collaborative learning/knowledge building purposes between students from different classrooms geographically dispersed. Given the obscure general awareness of the possibilities that Internet were opening for remote networked schools, a more attainable goal was set, that of enriching their learning environment so that it would become difficult for a school district to close such a school on the basis of underachievement.

Educational partners (teachers, school principals, school district administrators, and government public servants), brought together by a knowledge transfer agency named CEFRIO, were invited to engage in participatory design (Silva & Breuleux, 1994). According to Bereiter & Scardamalia (2003), the design mode is a process of working with ideas for solving real complex problems with no ready-made solutions, identifying and exploiting promising ideas. Design experiment/design-based research was the methodology of use. Ely's (1999) conditions of innovation with information and communication technologies (dissatisfaction with the status quo, available resources, available time, rewards or incentives for participants, expected and encouraged participation, commitment, and leadership) were monitored at least twice a year during a ten-year period (Hamel, Turcotte, & Laferriere, 2013). Co-design was favored (Voogt et al., 2015). Volunteer teachers engaged students into networked learning/knowledge building activities with the support of collaborative platforms – Knowledge Forum (KF) and a desktop videoconferencing system (iVisit) and, later, a web-based one (Via). A member of the research and intervention team (RIT) was available during working hours, in a virtual room of the videoconferencing system, to respond to on-demand practitioners' inquiries. Teachers were provided student participation data (e.g., numbers of written, read, revised, and linked contributions on KF, use of scaffolds, types of questions asked). RIT held meetings onsite/online to co-interpret data with school and school district partners. Research results pertaining to learning outcomes (e.g., students' vocabulary growth, reading comprehension and explanation level) were provided to educational partners for informed decision making.

In relation to the theme of the 2017 CSCL conference, it can be stated that the RNS initiative (2002-2017), now involving on a yearly basis over 6 000 students, 200 teachers 100 schools and 23 school districts, enlarges the digital use divide in the Province with teachers engaging students in advanced collaborative work while others do not. It can also be stated that the RNS helps reduced the digital use divide by engaging some rural school students in advanced uses similar to those some urban school students in North America and beyond may engage in. Scaling innovation is critical for addressing the digital use divide. For Engeström (1987, 2015), innovation occurs when an acculturation process takes place. In this short paper, we identify the organizational structures and interaction processes put in place as the RNS initiative was co-designed, and gained sustainability and scale while propulsing local practitioners at the upper end of the digital use divide.

Method

Building on Coburn's (2003) conceptualization of scale (four interrelated dimensions: depth, sustainability, spread, and shift [in ownership]), Dede (2006) suggested that evolution, meaning the learning that takes place for the original creators of an innovation while they interact with users, is an additional dimension to be considered. The depth dimension refers notably to teacher beliefs about classroom teaching and to what students can do when prompted to engage in unfamiliar interaction with their peers (e.g., knowledge building, Scardamalia, 2002; Scardamalia & Bereiter, 2006). Shift (in ownership) refers to local educational leaders taking charge of the innovation. We referred to these dimensions and applied an earlier draft of Law, Yuen and Lee's (2015) multilevel multiscale model that distinguishes eight different levels: international, system, school-university-government partnership, school district, school (leadership), teacher, classroom student, and technology. For each level, the organizational structures, the interaction processes and the technology put in place were identified as we revisited RNS technical reports (conditions of innovation put in place, teacher professional development, onsite/online activities, classroom learning/knowledge building artifacts). We present the organizational structures, interaction processes, and technologies that stood out.

Findings

Depth

There were no well-elaborated pedagogical materials to begin with (*technology*). The initiative tapped on teachers' agency, encouraging them to engage in new forms of interaction among themselves and with students (*organizational structure*). Volunteer teachers' beliefs about classroom teaching and what students can do were challenged (*interaction process*) through their uses of KF (*technology*). Administrative, technical and pedagogical support (*interaction process*) was provided. For teachers to come online, ask questions or talk about issues with a RIT member, trust had to be built (*interaction process*). RIT monitored the presence/absence of conditions for innovation and provided feedback iteratively (*interaction process*) during RNS district/school committee meetings (*organizational structures*).

The RNS initiative put forward a variety of educational practices (adult-adult, adult-student, student-student) using the collaborative platforms (*technology*). Participants reported on their activities onsite, online and at annual provincial knowledge transfer sessions (*organizational structure*), thus contributing to demonstrate the collaboration that could happen within and between networked schools. Regarding knowledge building (KB), a deliberate effort to increase the cultural capital of a community (Scardamalia & Bereiter, 2006), teachers and other educational partners at the system level have been introduced to its principles (*interaction process*). KF's affordances (e.g., neuronal presentation of notes, basic participation measures, scaffolds, promising idea highlight, analytical tools) and those of the videoconferencing system (e.g., a virtual room for on-demand technical and pedagogical support, identification code allowing teacher self-management of online classroom activities) informed and facilitated the conduct and analysis of written and verbal online discourse (*technology*). Both platforms presented constraints: Via required more bandwidth, equipment and time coordination; KF required the writing and reading of contributions (*organizational structure*).

Ongoing contact with RIT (*organizational structure*) allowed for online individual and small-group conversations on topics of interest to teachers (*interaction process*): how to focus students on a driving question? What to do with promising ideas? When to end a collective investigation? Gradually, the RNS website (www.eer.qc.ca) presented artifacts of collaborative inquiry by Quebec Francophone students (*interaction process*). Co-design as a form of professional development (Voogt et al., 2015) was practiced onsite/online between teachers from different classrooms and schools, and online with RIT members (*interaction process*). The Knowledge Building International Project (KBIP) (*organizational structure*) took professional development beyond local expectations (Laferrière et al., 2015).

Sustainability

Government funding endured but was reduced when another program provided subsidies to remote schools for their digital infrastructure (*technology*). CEFRIO remained the coordinating body (*interaction process*), and RIT kept providing professional development and research results (*organizational structure*). The two collaborative technologies that were part of the design of the RNS were challenged by IT school district departments wanting to roll in new "collaborative" technologies. The desktop videoconferencing system was replaced by a web-based one to the satisfaction of all but KF remained the main online written discourse platform (*technology*).

Spread

In 2008, the Government financed an Anglophone collaborative initiative across classrooms (*organization structure*). Recently, the Government expanded the limit number of school districts that could receive funding for participation, and the RNS initiative was renamed "The networked school" initiative (*organizational structure*). A growing number of Quebec urban private and public schools and France's rural academies are becoming interested in the model as they see what teachers and students accomplish with KB (*interaction process*) and KF (*technology*).

Shift (in Ownership)

Some school districts modified their school funding policies and provided for some teachers to work in their classroom four days a week, and devote the fifth day to the induction of volunteer colleagues into RNS practices (*organizational structure*). A governing body was established (*organisational structure*), composed of four school district superintendents, and representatives of Ministry of Education, Quebec Federation of school districts. The CEFRIO's representative became the director of the initiative. The KF server remained university-based, and a research center of which RIT was a member (*organizational structure*), offers on-demand support (*interaction process*), including server maintenance and upgrade (*technology*).

Evolution

RIT's valuing of the agency of the educational partners involved was put to test many times. RIT learnt to work within the zone of proximal development, and deal with tensions/contradictions between principle-based design and provincial/district policies, norms, procedures and routines (*organizational structure*). The virtual community, composed of elementary, secondary and postsecondary Francophone teachers engaged in KB practices (*organizational structure*), has its ups and downs (*interaction process*) but new ways to move ahead locally and also to participate in the international KB community are found.

Discussion

Facing together the problem of quality of education in small remote schools, educational partners envisioned that teachers from different schools could establish viable collaborations among themselves and among students (*organizational structure*). Their co-design rested on collaborative platforms, one for written discourse and the other for verbal discourse (*technology*). In best instances, the combination of the two platforms afforded deeper student understanding of authentic problems through collaborative inquiry.

This analysis of the depth, sustainability, spread and shift (in ownership) dimensions uncovers two double-binds. The first pertains to "spread" without "depth" or "depth" without "spread". "Spread" without "depth" occurred when teachers and students used the videoconferencing system to do time consuming surface activities (e.g., having students introduce themselves one after the other in a repetitive manner) or when students wrote on KF repetitive notes in response, for example, to a question originating from a teacher instead of a question growing out of a classroom discussion. The RNS initiative also had "depth" without "spread". For instance, some teachers guided students to improve promising ideas and develop a collective understanding of a question or problem but this practice did not spread. Another double-bind reflects a tension between "sustainability" and "evolution". RIT's thinking was that teachers willing to engage in collaborative activities were boundary spanners, not followers. It counted on teachers' agency, and therefore on their capacity to adapt and take advantage of the affordances of the collaborative technologies in a sustainable manner. But teachers, who had to cope with daily obligations, were asking for exemplars and more resources. RIT responded by developing some resources. Coburn and Stein (2010) stressed the importance of available teaching/learning activities and materials for innovation. Over the years, activity exemplars and materials were co-created with teachers (e.g., Allaire & Lusignan, 2011).

This analysis adds to Chan's (2011) three interacting themes (context and systemic change, capacity and community building, and innovation as inquiry), two other themes: 1) Ongoing use of up-to-date collaborative platforms, and 2) participation in a network. See also Clarke, Dede, Ketelhut and Nelson (2006), Coburn and Stein (2010), Coburn, Russell, Kaufman, and Stein (2012). We suggest that these five themes are critical for addressing the digital use divide in socially responsible ways.

Conclusion

Given that the first-level divide (access to digital technology) has been significantly reduced, the US National Education Technology Plan (2016) highlights the challenge of the "digital use divide" (second-level divide). It is a call to which one can respond by engaging in partnership research, or research-practice partnerships (Penuel, Fishman, Haugan Cheng, & Sabelli, 2011), committed to bring innovation to scale. It is a challenging task but one worth pursuing as third-level divides, according to Van Deursen and Helsper (2015), are now appearing. These authors defined this new generation of divides as "disparities in the returns from internet use within populations of users who exhibit broadly similar usage profiles and enjoy relatively autonomous and unfettered access to ICTs and the internet infrastructure" (p. 30). They add: "The internet remains more beneficial for those at the highest education levels, with higher social status, not in terms of how extensively they use the technology but in what they achieve as a result of this use for several important domains." (p. 46).

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Preparing Pre-Service Early Childhood Teachers to Teach Mathematics With Robots

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Abstract: This study exposed early childhood pre-service teachers to robotics and help them teach mathematics with robots. People tend to treat not only themselves but also others within the scope of the stereotypes that they experienced. Stereotypical conceptions about certain subjects and occupations are formed in early life. The cycle of stereotype threats could be broken by exposing early childhood pre-service teachers to robotics that requires them to build and program robots and design of mathematics lessons using robots.

Introduction

This paper reports on pre-service early childhood teachers' learning with robotics for teaching. Specifically, their integration of robotics into mathematics teaching in their lesson designs was examined. Their perceptions of gender stereotype threats were also examined. This paper is aligned with CSCL's "Strand 2: Access and Equity in High Quality Knowledge" in that it reports a study in which computer-supported collaborative learning was facilitated through group robot assembly, programming, and lesson designs, with the ultimate goal of improving gender equity in early childhood education.

Relevant literature

Most efforts to boost science, technology, engineering, and mathematics (STEM) career interest focus on middle and high school (George, Neale, & Van Horne, 2001; Olson & Riordan, 2012; Tyson, Lee, Borman, & Hanson, 2007). While such settings are important, if one waits until middle and high school to address intentions to pursue STEM career pathways, it may be too late (Ralston, Hieb, & Rivoli, 2013). For example, career interest at an early age critically influences life-long decisions (Archer et al., 2013; Maltese & Tai, 2010). Occupational aspirations tend to be stable during adolescence and earlier aspirations determine career choice and pursuit of educational opportunities (Rojewski & Yang, 1997).

Stereotypical conceptions about certain subjects and occupations are formed in early life (Tuijl & Molen, 2016), and can cause members of underrepresented groups to attribute poor performance to such ideas as "girls can't be good at math" (Appel & Kronberger, 2012; Cvencek, Meltzoff, & Greenwald, 2011; Thoman, Smith, Brown, Chase, & Lee, 2013). Elementary school girls, 2nd graders, identified themselves with math less than boys (Cvencek et al., 2011). Attributing failure to such factors can lead to low self-efficacy, because such students see their failure as resulting from a stable cause (e.g., gender, ethnicity; Weiner, 1985). Before students are "locked in to a particular orientation toward occupations", the effort to create optimal environments is needed during elementary years (Rojewski & Kim, 2003, p. 140).

Central to this effort is a need to prepare pre-service early childhood teachers to provide success opportunities in STEM for all students. Teacher beliefs and expectations influence students (Jussim & Harber, 2005). Female students are not included in the high math performer group as many as male students are, from kindergarten to eighth grade (Robinson & Lubienski, 2011). Female students were 15% of the top 1% in kindergarten and 37% of the top 1% and 40% of the top 10% in eighth grade. Such persistent gender disparity seems related to teachers' gender stereotype that impacts their beliefs about math ability and efforts of lower to average achieving students (Tiedemann, 2002). Without these lower to average math achieving students' moving close to the top, females would continue to be part of the underrepresented group in STEM careers (Robinson & Lubienski, 2011).

Preparing early childhood pre-service teachers to be positive role models to young girls can help. One strategy that can lower stereotype threat is exposing students to positive role models who contradict stereotypes (Marx & Goff, 2005; Marx & Roman, 2002). Positive role models who are female and competent in math and other STEM-related skills can help young girls "buffer their self-appraised math ability" (Marx & Roman, 2002, p. 1183).

The current study exposed early childhood pre-service teachers, all female, to robotics and help them teach mathematics with robots. People tend to treat not only themselves but also others within the scope of the stereotypes (Thoman et al., 2013). When early childhood pre-service teachers consider themselves as a non-math person because they are female (Kim et al., 2015), such a stereotype could be modeled by young girls in their future classroom. The cycle of gender stereotype threats could be broken by exposing early childhood female pre-service teachers to robotics that requires them to build and program robots and design of math lessons using robots.

Robotics was chosen because it has shown to promote STEM interest and learning and has been used in teacher education (e.g., Sullivan & Moriarty, 2009). However, it has been rarely used in preparing early childhood teachers to teach STEM despite the potential benefits of robotics for young children (Bers, Flannery, Kazakoff, & Sullivan, 2014). Especially, teaching mathematics with robotics has not been developed as much as science, technology, and engineering (Silk, Higashi, Shoop, & Schunn, 2009). Mathematical connections are often overlooked among teachers in teacher preparation contexts using robotics (Kim et al., 2015).

Research questions

In this study, the following research questions were addressed:

1. How do the early childhood pre-service teachers design robotics in mathematics teaching?
2. How do the early childhood pre-service teachers perceive stereotypical threats?

Methods

Research design

The study employed qualitative research design using open-coding, thematic analysis, and content analysis (Creswell, Clark, & Gutmann, 2003).

Participants

Participants were eleven early childhood pre-service teachers enrolled in an undergraduate course for hands-on learning in early childhood education. They engaged in robotics for four weeks as part of the course curriculum (see Figure 1). All were female and had no experience with robotics and programming prior to the study. The research site was a public university in the United States.

Figure 1. Collaborative Robot Building.

Data collection and analysis

Data sources were lesson designs and semi-structured interviews. To address RQ1, content analysis was conducted in seven lessons collaboratively designed by the participants. We examined the grade levels and math content addressed, the methods and affordances of robotics use, and collaborations designed for students. The 4-researcher team discussed lesson analysis strategies, one experienced researcher analyzed one lesson and shared it with the team, the team discussed the analysis, two other researchers analyzed the rest, and the team again discussed and revised their analysis where needed. In addition, interviews were analyzed to examine participants' mathematics teaching with robots. To address RQ2, interviews were analyzed. Nine out of eleven participants were interviewed for 20-30 minutes each. The statements (e.g., "Males are much more talented in math than females") used to assess one's stereotype threats in the literature such as Mayer and Hanges (2003), Picho and Brown (2011), and Tiedemann (2002) were applied to construct a coding scheme (e.g., situation-specific stereotypes, generalized stereotypes) in identifying and analyzing participants' comments from interview transcripts. For example, such comments as "I'm not great at math… but I like reading" were identified first and a thematic analysis was conducted to record themes (Miles & Huberman, 1984) related to stereotype threats.

Results

The grade levels targeted in lessons ranged from kindergarten to fourth grade: 2 lessons for kindergarten, 1 lesson for first grade, 2 lessons for second grade, and 2 fourth grade. Participants were allowed to target upper elementary levels. Participants were not required to include mathematics. Among seven mathematics lessons, five were interdisciplinary, integrating science, art, and language arts into mathematics teaching. Mathematics content included force and measurement, geometry shapes, friction and measurement, counting numbers and measuring distance, and different types of terrain and measurement. The common mathematics content was measurement and geometric shapes. These content utilized robotics affordances such as (a) robots can be programmed to execute specific commands and (b) a robot travels with different speeds on different surfaces, which lends itself to measuring distances and representing the data. The following two comments illustrate participant reasoning for their mathematics content selection.

> We picked mathematics. We thought we could incorporate that [mathematics] with the [robot] building, but then when we looked more into second grade [mathematics] standards, that wasn't really a second grade standards, and we saw that they did a lot of graphing, so we thought they could do time trials with the robot and stuff, and we thought that, with it, that would be, like, gateway into robotics, just graphing. It was something that they would be familiar with, and they could tie that together with their robots.

> Especially with kindergarten because they're not really, they don't really know how to write and read, and math isn't really their strongest suit, so I think shapes was... a good, artistic way to pull them in.

Students collaborated in these lessons by measuring the distances robots run and recording data, editing their peers' writings on their observations of the distances robots running along different slopes, talking about their favorite parts of the robotics activities they performed in the class, programming robots, writing robot stories, building a town with trails for robots to travel on, and making hypothesis of a robot running on trails built with different materials.

The interview data analysis results with regard to stereotype threats reveal that participants frequently acknowledged their lack of knowledge of STEM, resulting from (a) no talent in mathematics and (b) no exposure to STEM growing up. For example, one participant said, "I'm not great at math… but I like reading." This remark seemed to imply that, to like reading, you can just like reading without being good, but to like math, you have to be a math (talented) person. In addition, the following comments illustrate that female pre-service early childhood teachers in this study were exposed to the learning experience that has helped them more self-efficacious about STEM than ever before:

> I never really knew much about STEM growing up and everything. And then I wasn't really into technology and stuff like that, but [now I've done robot assembly and programming] it's not as hard as someone who doesn't know about it thinks that it is.

Discussion

Data analysis results will be presented in detail during our presentation.

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Collaborating With Stakeholders in STEM Studios

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Abstract: Studio-based learning provides an environment in which a collaborative, problem-based approach to learning Science, Technology, Engineering and Mathematics (STEM) is encouraged. In this project, the STEM Studio approach was used with school students in formal and informal learning environments for preservice teacher education. Building on research from orchestration and learning analytics identifying stakeholders, and part of a nationally funded, multi-institutional project, we examine the complexity and diversity of communities in three STEM Studios. Using multiple data sources, the aim of this paper is to identify the stakeholders and the relationships between them in order to visualize the complexity of the networks and to compare (1) changes in networks over time; (2) differences between the learning contexts; and (3) the implications for preservice teacher education.

Introduction

Interest is growing in collaborative, constructive, problem-based approaches to learning knowledge and skills in STEM (Science, Technology, Engineering and Mathematics). Studio approaches (Brandt et al., 2013) encourage learners to link core disciplinary knowledge to solve a given problem. With investments by schools and universities in new learning spaces, teachers are incorporating many elements from these informal settings. In order to provide appropriate training for preservice teachers, it is important to understand considerations for the design of STEM units of work, and one important factor is stakeholder collaboration and coordination.

We report on research from a project that investigated the application of studio-based approaches to preservice teacher education using a *STEM Studio* approach. Part of a nationally funded, multi-institutional project, three variations of the STEM Studio are compared: formal education with secondary students; informal education with middle school students; and informal education with primary students. Using video and audio recordings to inform researcher observations, interviews with participants, and questionnaire data, we identify the stakeholders and the relationships between them to visualize: the complexity of the networks; changes in networks over time; differences between learning contexts; and implications for preservice teacher education.

Background

The studio approach to teaching and learning has a history in areas such as architecture or industrial design (Brandt et al., 2013). The studio approach is a variant of project based learning, and core features are iterative design, and self-reflection (Brandt et al., 2013; Hoadley & Cox, 2009). Schon (1987) suggested that this approach could be adopted in any discipline area, and since it has been applied in STEM disciplines (e.g. Shaffer, 2005). The studio leverages opportunities to engage students in rich and open-ended challenges that require and support complex problem solving, application of multi-disciplinary knowledge and fosters the enactment of creative strategies. With teaching more readily considered to be a design profession (Laurillard, 2012), there has been a movement towards adopting a studio approach to preservice teacher education. In this study, we used the studio model to create a "third space" (Zeichner, 2010, p.89) in which pre-service teachers could practice innovative pedagogy and develop pedagogical content knowledge in relation to a range of contemporary STEM topics. The third space provides a temporary learning community for collaborative self-study and professional learning where participants seek new experiences, approaches, and roles in their teaching practice. Using the third space distances preservice teachers from the pressures of assessment of their practice as experienced in both schools and university settings, and encourages collaborative and reflexive practice.

An important factor in the success of studio approaches in informal learning environments is the access to expertise with the creative community. In formal education, this requires stakeholder collaboration and coordination. Research on the design of CSCL has focused on stakeholders related to design and research (e.g. Rose et al., 2016), as well as those related to enactment in the classroom (e.g. Prieto, Dimitriadis, Asensio-Pérez & Looi, 2015). We used an iterative method to identify stakeholders, their influence on the design and enactment phases, and relationships between them (Bryson, 2004). We adopt Goodyear, Jones & Thompson's

(2014) definition of CSCL, which refers to situations in which computer technology plays a significant role in shaping the collaboration, whether online, face-to-face, visualizing activity, or scaffolding learning, and argue that teachers need to be provided with tools to identify stakeholders in STEM Studio approaches, as well as to collaborate during design, enactment, and assessment. We produce stakeholder maps of the relationships before and after the STEM Studios to identify the interactions that exist beyond the peer-to-peer or student-teacher interactions in the classroom. It is this complex network that we seek to capture, with the view to better understand activities such as the STEM Studio approaches, and, more generally, the design work of teachers.

Methods

The STEM studio model was replicated in three university settings in Queensland, Australia, with each setting adapting the model so as to respond to relevant resourcing and demography constraints within each situation: formal education of high school students; informal education of middle school students; and informal education of primary school students. Common to each variant of the STEM Studio model were the interactions in the exploratory third space between STEM experts, mentor practicing teachers and novice preservice teachers.

High school students (formal education) consisted of design challenge based activities within a school based STEM program. The model involved collaboration between classroom teachers, preservice teachers, teacher educators and STEM experts to design, develop and deliver transdisciplinary, problem-based STEM units of work. The design of the STEM units of work was inspired by the core tenets of Universal Design for Learning (Courey, Tappe, Siker & LePage, 2013) and the Exploratorium (The Art of Tinkering, 2015). A core feature was that students, preservice teachers and classroom teachers worked with STEM Experts on contemporary research problems. The STEM Experts included PhD students and academic staff from a range of disciplines (e.g. Astrophysics, Biomedical Science, Civil Engineering, Robotics). STEM experts were involved during the design and enactment of STEM units of work. They collaborated with the preservice teachers via email, phone, and face-to-face to discuss the unit of work, concepts, ideas and real world examples. For each of the 19 STEM Studios offered, one STEM Expert was selected based on the topic area chosen by the school. Each comprised of four meetings, and STEM experts participated in the classroom in at least one of these. *Middle school students (informal education)* involved a structured, out-of-school, STEM enrichment program open to young people in years 5-8 in the district surrounding the host university, in regional Australia. The Commonwealth Government, a local museum, and the local City Council, City Libraries program provided support that included human resources and physical spaces to meet. Preservice teachers volunteered to facilitate the STEM Studio meetings for credit towards community service. Each week, the preservice teachers worked with an experienced STEM educator, supported by a teacher educator who mentored the inquiry-based pedagogical approach, as well as STEM Experts from the fields of medicine, geology and biology who assisted with three of the fifteen weekly activities. Over 15 weeks, 50 school students attended the program. *Primary school students (informal education)*, was carried out in the science teaching labs at the host university. During an existing Outside School Hours Care (OSHC) program, students, years Prep-6, and staff were invited to attend the STEM Studio for up to two hours per week, for eight weeks. The STEM Experts included graduate engineering students. The STEM Experts and the pre-service teacher volunteers were offered training focused on an inquiry-based pedagogical approach. During the STEM Studio, students were given structured information about STEM methods of inquiry, and undertook a design exercise to identify their final project. They formed groups based around common interests and identified three projects: (1) making a three piece ice-cream machine; (2) Bunsen burner investigations; and (3) programming and robotics.

Stakeholder maps were constructed for each setting to depict the stakeholders and interactions before and after the STEM Studio. The maps were created using a process similar to Bryson (2004). The first step was to identify the key stakeholders and rank their importance as major or minor based on time, influence, and support (represented in Figure 1 by the circle size). Researcher observations were used to identify stakeholders, and researchers from each institution discussed and agreed upon the classification in terms of student learning and pre-service teacher education. The second step was to identify relationships between stakeholders and classify these according to personal, professional or occasional (represented on the map by the weight of the line). The identification and classification was determined using the results of questionnaires, interviews, as well as observations by researchers in the STEM Studios as well as video and audio recordings. The stakeholder maps are presented in the results section. Interview data with stakeholders was also used to consider the implications of stakeholder relationships for the design of STEM Studios and pre-service teacher education.

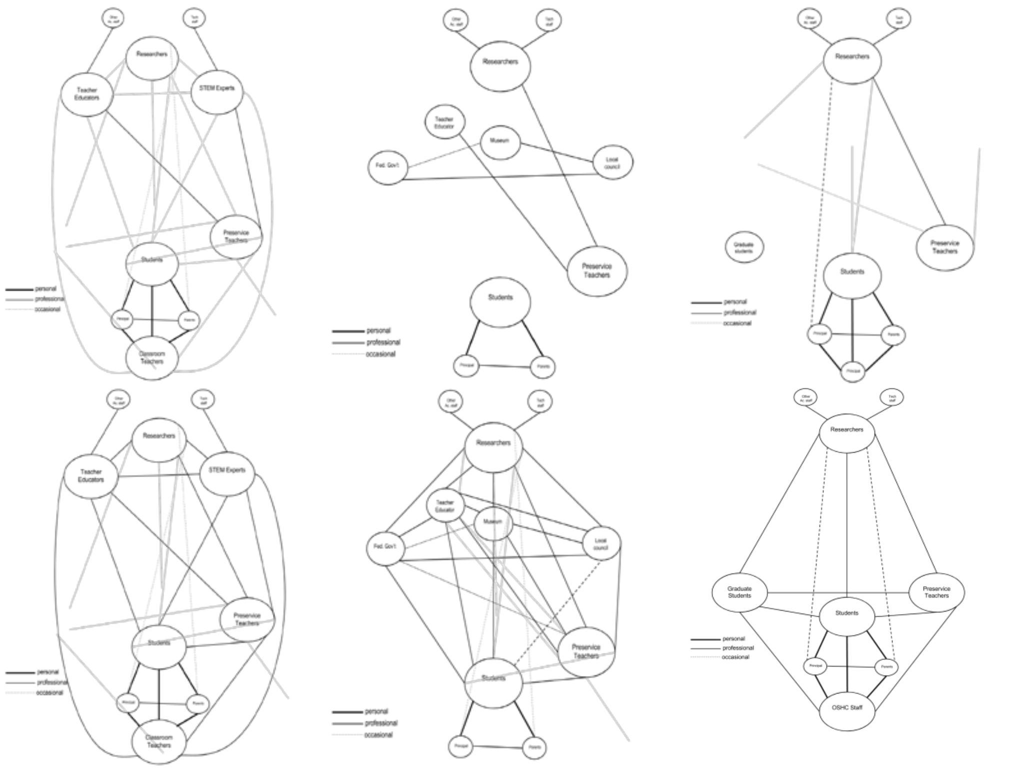
Results and discussion

The stakeholders were identified for each of the STEM Studios in terms of design as well as enactment. The identified stakeholders included individuals from the host Universities (researchers, STEM Experts, preservice teachers, technical staff and teacher educators); schools (classroom teachers, students, principals, parents), and other (Commonwealth Government, Museum, Local Council, and Out of School Hours Care (OSHC) staff).

Each of the STEM Studios was characterized by a different configuration of stakeholders, with influence specific to the purpose of their involvement. The high school STEM Studio included teacher educators as influential stakeholders, the middle school STEM Studio considered the teacher educators to be moderately influential, and the primary school STEM Studio did not include teacher educators as stakeholders. The middle school STEM Studio involved important interactions with other government groups (e.g., museums), whereas the primary school STEM Studio was conducted through the outside school hours care (OSHC) program. Differences between the design phase and enactment were observed in the influence assigned to stakeholders. In the primary school STEM Studio the influence of the STEM Experts was greater during enactment, as were the OSHC staff. The strength of relationships between these stakeholders were then determined These resultant stakeholder maps can be seen in Figure 1, which show the relative importance of the stakeholders by the size of the ellipses and the strength of the interaction by the weight of the connecting lines.

Design phase

Enactment



High school students   Middle school students   Primary school students

Figure 1: Stakeholder maps for STEM Studio contexts, before and after the STEM Studio.

Examination of the design phase maps shows few interactions between the stakeholders. Small, sub-networks existed within institution types, such as the school based networks and that between the community organisations in the middle-school situation. During enactment, the number of relationships increased, as did the complexity of the networks. In addition to highlighting the differences between the designs of each of the three STEM Studio variants, Figure 1 also demonstrates the difference in the focus. In the high school situation, the focus is on preservice teachers. In the middle-school student stakeholder map, the focus is more balanced, with many layers of network. The primary-school student stakeholder map shows the increased influence of OSHC staff and STEM experts, during enactment. The number of connections was expected to be greater during enactment, however, this did not occur uniformly, and the data collected through interviews and questionnaires can help to understand the implications for preservice teacher education.

Initial analysis of the questionnaire data for the high school and primary school situations showed positive changes in preservice teacher self-efficacy after teaching in the STEM Studio, particularly in regard to effective instruction, motivating students and coping with change in the classroom. In both, preservice teachers worked with a variety of stakeholders including experienced educators (classroom teachers and OSHC staff). The importance of the collaboration is supported through the interview data in the high school situation: "This strong collaboration between top scientists, tertiary educators and high school students has been an excellent way to inspire students through engaging in innovative learning activities." (classroom teacher). In the middle-school situation, preservice teachers reported a high level of confidence in developing approaches for communication with school students, but moderate for STEM knowledge and skills, and for pedagogical knowledge related to inquiry approaches. The middle school situation is by far the most complex. Initial attempts to form a STEM Studio without broad community connections were unsuccessful. The resourcing required to initiate and support the STEM studio model could only be realised through a partnership approach. Each of the identified community partners corresponds to a different physical STEM Studio, and the STEM experts at each influenced the learning outcomes identified through thematic coding of the qualitative responses about what students learned. Those at the Museum reported development of knowledge and understanding, while those located at the University reported on a sense of creativity, inspiration and enjoyment, both reported similar identification of learning of skills.

Conclusions

As schools and universities move towards more inquiry and project-based learning approaches to teaching and learning, particularly within the STEM fields and preservice teacher education in the STEM fields, we need to understand the necessary factors for the success of such approaches. We sought to expand our understanding to include the many stakeholders involved. In doing so, we considered the complexity of interactions that teachers need to account for in the design of STEM Studios, and thus, how we prepare them to do so. This goes beyond collaborative teaching, and moves closer to understanding some members of these networks as part of an interdisciplinary team of educators, all of whom contribute expertise about pedagogy, subject matter, or about the learners themselves. We need to prepare our preservice teachers to lead interdisciplinary teams of educators, with computer-based tools to support collaboration, if they are to negotiate the complexity of project-based learning approaches as observed in STEM Studios. Future work will consider these networks of stakeholders in terms of power relationships and the identification, role and impact of key stakeholders.

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Challenges in Implementing Small Group Collaboration in Large Online Courses

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Abstract: Large online courses typically suffer from a lack of possibilities for social interaction among participants. One approach for facilitating social interaction is small group collaboration. Successfully implementing small group collaboration in online courses, however, is not an easy task. In two iterations of a large online course, we first identified implementation problems and their possible causes (Course 1: N = 270), and subsequently tested possibilities of mitigation and corresponding improvements (Course 2: N = 111). The problems identified in Course 1 included a high dropout rate, low participation in group work, and low course satisfaction. These are typical problems in large online courses. However, their significance increases when they occur in the context of small group collaboration. Changes on the structural but also on the social level in Course 2 improved course satisfaction, but did not lower dropout rate nor did it increase participation in group work.

Introduction

Large online courses are increasingly used as a format of instruction in higher education. The presupposed affordances of these courses are that they are resource efficient and allow for more flexible time management than traditional courses. They are therefore assumed to fit every student's time schedule and thus to reach a broader student population (Hollands & Tirthali, 2014). However, typical problems in large online courses are that students exhibit motivational deficits, time management issues, and lack of individual accountability, which results in high dropout rates (Yang, Sinha, Adamson & Rosé, 2013). Research provides evidence that social interaction in the form of small group collaboration has the potential to counteract these problems (Rosé, Goldman, Zoltners Scherer & Resnick, 2015, Machemer, 2007). However, so far, in most large online courses the focus lies on individual learning activities.

Making small group collaboration successful is a major challenge, even in traditional classroom settings (Asterhan & Schwarz, 2016). When collaboration takes place in a computer-mediated setting, making the group work successful is an even greater challenge, because the cues that facilitate communication in face-to-face interaction are reduced. Thus, the participants' required effort to communicate effectively is higher (Clark & Brennan, 1991). One of the requirements for effective group collaboration is the participants' active engagement in explorative and discursive meaning making processes (Herrmann & Kienle, 2008). Research in CSCL shows that intensive support of these processes is necessary to ensure successful learning. This support is often given in the form of scripts (Weinberger, Stegmann & Fischer, 2010). In addition to such scripts, the instructor's support (Kearsley, 2000) or sophisticated computer-generated adaptive support (Rosé et al. 2015) is also important for effective small group collaboration. Most of the research on small group collaboration in online courses concerns courses with only a very small number of participants, allowing for intensive support by the instructor. In research on online courses with a high number of participants the group work is mostly project-oriented and on a voluntary basis (e.g. Rosé et al., 2015), which means students are likely to be highly intrinsically motivated.

Given the characteristics of previous research, the following question comes to mind: do the positive effects of small group collaboration also occur when the number of participants does not allow for intensive support of the collaborative process or when students do not participate on a voluntary basis? As active participation can be seen as a prerequisite for small group collaboration to be effective, our studies had two aims. The first aim was to investigate whether students actively participate in mandatory small group collaboration in large online courses. The second aim was to identify challenges associated with active participation, and to investigate how these challenges can be overcome to successfully implement small group collaboration into these courses without continuous adaptive support (from instructors or computer generated). Our approach is of interest for distance education as well as for universities that run online courses on-campus, and for large online course formats such as Massive Open Online Courses (MOOCs).

Methods

To achieve our goals, we ran two consecutive large online courses at university level, for which students could receive credits. In both courses, participants collaborated in small groups of three or four students in several iterations. We analyzed the data of Course 1 to identify possible challenges of small group collaboration, and tested the effectiveness of a re-design to address these challenges in Course 2.

Course 1

Course- and group work design

The subject of the course was "psychological principles of computer mediated communication". It included topics like "Transactive Memory" and "Scripting in CSCL". Moodle, which was used to run the course, is a commonly used learning platform in higher education. Participants had the possibility to engage in different learning activities and interact with various materials: an introductory video, relevant literature, quizzes and individual as well as collaborative assignments. Completing the assignments and the quizzes was mandatory for receiving the course credits. The study was conducted as part of an online university-level course. The course was open for students of different study programs at Ruhr-Universität Bochum and the University of Duisburg-Essen. Of 324 course participants, 270 participants gave their consent to include their data in our research. The course ran for a total of 14 weeks.

As already mentioned above, the course consisted of several types of course activities, including six small group collaboration phases in the second half of the course (phase 1: $n = 72$ [18 groups]; phase 2: $n = 63$ [16 groups]; phase 3: $n = 62$ [16 groups]; phase 4: $n = 123$ [31 groups]; Phase 5: $n = 122$ [31 groups]). The group collaboration of one phase could not be included in the data analysis due to technical difficulties. The different numbers of participants in the different phases are due to the dropout rate as well as the structure of the course, as in phases 1, 2 and 3 half of the participants did not work collaboratively but individually. In each of the four phases, participants were randomly assigned to small groups of three to four group members each. To avoid repeated inclusion of non-active participants, participants were dismissed from the course if they missed two or more assignments or quizzes. In each phase, students wrote a text to answer an open-ended question about the contents of that particular week. To allow students flexibility in time, we chose a written format which did not require students to work synchronously on the task. Students were supposed to discuss and coordinate in a group forum and collaboratively produce a written text in a real-time text editor. To solve the tasks, it was not enough to reproduce knowledge from the provided learning activities and materials (such as video and literature). Instead, conceptual knowledge construction (e.g. through explorative learning activities and self explanation) was needed for a correct solution. This type of task was supposed to ensure that participants felt the need to interact with each other in order to correctly solve the task (see Dommel & Garcia-Luna-Aceves, 2000). In addition, the tasks were slightly scripted (e.g. through the allocation of roles). The available time for completing each collaborative task was four days.

We assessed students' motivation (at the beginning and at the end of the course) and course satisfaction as well as usability of the system as perceived by students (at the end of the course) via surveys. Course-related intrinsic motivation was measured with the IMI (Intrinsic Motivation Inventory) consisting of 24 items on a seven-point likert scale. Satisfaction with the online course was measured with a single item on a seven-point likert scale ("I liked the online course"). We measured students' perceived system usability with the System Usability Scale (Brooke, 1997) consisting of ten items on a five-point likert scale.

Data analysis and results

We analyzed the following variables: dropout rate, participation in group work (relative number of groups with one or more inactive members) as well as motivation, system usability, and course satisfaction.

Of 270 participants at the beginning of the course, 122 were still active at the end of the course. This leads to an overall dropout rate of 55%. In all four phases, the relative number of groups with one or more inactive group members was 33-48%. Motivation at the beginning of the course ($M = 3.31$; $SD = .81$; $n = 106$; min =1; max=7) was higher than motivation at the end of the course ($M = 2.81$; $SD = .10$; $n = 27$; min: 1 max: 7).

The distributions of the results in system usability (M = 2.91; SD = .29; n = 64, min: 1 max: 5) and course satisfaction (M = 2.98; SD = 1.30; n = 43; min: 1 max: 5) were slightly skewed to the left.

Discussion

Typical problems for online courses were encountered, namely low participation and a high dropout rate. These phenomena are very well known for large online courses but they are of special relevance in the context of small group collaboration, since they lead to groups with an insufficient number of active group members. Low participation, in turn, may lead to frustration and reluctance to participate for the remaining group members, in the active group members and thus further decrease active participation. This hinders collaborative learning to take place. Frustration and reluctance may be reflected in the declining course-related intrinsic motivation throughout the course. Even though participants were dismissed from the course when they did not participate in the assignments for two or more times and the dropout rate decreased throughout the progression of the course, the rate of groups with one or more inactive group members did not fall below 33%.

As organizational factors are extremely important for successfully running a large online course, shortcomings on the organizational level may explain why low participation and high dropout rates occurred in the first place. Most participants had no experience with online-courses. Hence, some of them did not check for announcements in their email, and did not see the announcements on a news forum because they did not log in to the platform regularly. This led to confusion with respect to current activities and upcoming deadlines.

Course 2

Course- and group work design

Our aim was to increase active participation by improving the course structure and by taking measures to promote more effective communication in the course. We aimed to achieve these improvements by: 1) increasing the clarity of the platform by changes in structure and layout; 2) more distinct communication about activities and deadlines through more than one communication channel. Upcoming deadlines were now posted in a sidebar that was always visible to the students and additionally in a document that provided an overview of the activities for the whole course. In addition, if something important needed to be communicated, an email was sent to all participants; 3) extending the group work phases to a period of seven days. This gave participants more time to get organized and increased their possibilities to interact with each other; 4) asking participants to confirm their participation in the next upcoming course unit. Participants were only included in the upcoming group work if they confirmed their participation. Participants were allowed to be absent from group collaboration two times throughout the course. This was supposed to help reduce the amount of inactive group members and to raise students' flexibility as well as increase commitment and individual accountability. To promote social presence and community building, we implemented an icebreaker session where everyone was asked to briefly introduce him- or herself and post his or her favorite find on the internet (e.g. a video or picture). Apart from the aforementioned changes, the course design was the same as in Course 1. The course was again open for students of different study programs at Ruhr-University Bochum and the University of Duisburg-Essen. Of 149 participants, 111 gave their consent to include their data in our research. The course ran for a total of 13 weeks.

The design and procedure of small group collaboration was the same as in Course 1 except for the available time for completing each collaborative task (seven days instead of four days). Course 2 included four iterations of small group work in weeks 6, 8, 10 and 12 of the course: phase 1: n = 76 (20 groups); phase 2: n = 37 (10 groups); phase 3: n = 34 (9 groups); phase 4: n = 63 (16 groups).

Data analysis and results

The same analyses were performed as in Course 1. Of 111 participants at the beginning of the course, 57 were still active at the end of the course. Thus the dropout rate was 49%. In the four phases of collaboration, the relative number of groups with one or more inactive group members was 33-53%. System usability (M = 3.84; SD = .70; n = 18; min: 1 max: 5) and course satisfaction (M = 4.00; SD = .88; n = 19, min: 1 max: 5) were relatively high. The motivation questionnaire could not be used for analysis due to technical difficulties, unfortunately.

Comparing Course 1 and Course 2

No improvement was found concerning the dropout rate (Course 1: 55%; Course 2: 49%), nor concerning the relative number of groups with inactive group members (Course 1: 33-48%; Course 2: 33-53%). Concerning the self report measures, t-tests revealed significant differences between the courses for system usability (Course 1: $M = 2.91$; $SD = .29$; $n = 64$ vs. Course 2: $M = 3.84$; $SD = .70$; $n = 18$): $t(80) = -8.402$; $p = .001$., $d = 2.253$ and course satisfaction (Course 1: $M = 2.98$; $SD = 1.30$; $n = 43$ vs. Course 2: $M = 4.00$; $SD = .88$; $n = 19$): $t(60) = -3.121$; $p = .003$, $d = 0.933$.

Overall discussion and outlook

In two iterations of a large online course, we were able to identify low participation and high dropout rate as substantial problems in small group collaboration. These typical issues do gain special significance in the context of small group collaboration, as they lead to an insufficient number of active group members. Hence, in groups with low participation, (effective) small group collaboration cannot take place.

In order to counteract these problems, we identified possible shortcomings in communication and clarity of the platform and implemented improvements in Course 2. Perceived system usability and course satisfaction did increase significantly. However, the active participation into group work did not increase, nor did the dropout rate decrease.

Thus, the results imply that the changes that mostly concerned the organizational level of the course, were perceived useful. However, the fact that the changes were not effective regarding the reduction of inactivity and dropout rate raises one major question: How can small group collaboration have positive effects on active participation, motivation and learning outcomes when there is not enough activity and motivation for small group collaboration to occur in the first place? Without active student engagement in group work, the positive effects of group work cannot occur. We hypothesize that without intensive supervision from instructors, active student participation is hard to achieve.

As the focus of our studies lay on improvements on the organizational level, we suggest that future research investigates whether active participation in group work in large online courses can be increased by changes on the social level (e.g. creating more positive interdependence among the group members; see Johnson & Johnson, 2014). Our own future plans for research includes investigating whether participants' contribution to group work correlate with their other activities in the online platform. The goal would be to identify behavioral patterns to characterize participants with low collaborative activity (and possible dropout) as well as students with high collaborative activity.

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Collaborative Intelligent Tutoring Systems: Comparing Learner Outcomes Across Varying Collaboration Feedback Strategies

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Abstract: In this paper, we present a collaborative extension of our ITS for Computer Science (CS) Education. The design of the collaborative version was motivated by noted benefits of collaborative learning including heightened retention of underrepresented students, particularly as demonstrated through pair programming within the CS domain. In this paper, we examine the outcome of two designs of the collaborative system with varying degrees of collaboration feedback. In the *unstructured* version, pairs are presented with no collaboration feedback while in the *semistructured* version of the system, pairs are given visual feedback in regards to their group and individual performance. We collected log data of system use as well as audio recordings of pairs. We found that students in both conditions experienced significant learning gains. Shifts in dialogue initiative where significantly positively correlated to learning gains in both conditions. However, students provided with additional collaboration feedback, exhibited less planning and overall symmetry.

Introduction

This study offers a comparative analysis on the effect of collaboration feedback within a collaborative tutoring system for Computer Science (CS) Education. The work synthesizes findings from the research domains of CSCL, ITS, and CS Education, and thus offers a foundational perspective on a growing area of Collaborative Intelligent Tutoring Systems (CITs). The study aims to provide insights on how pairs respond to performance feedback as well as the effect of tutor collaboration structuring on planning, symmetry, and learning gain.

While Intelligent Tutoring Systems (ITS) have offered a viable solution to the issues of automation and scalability, they have also been traditionally geared toward one-on-one, student-tutor. However, the growing model of CS Education has shifted to an emphasis on collaborative work and has resulted in higher retention rates of underrepresented students and better learning (Porter et al., 2013). Specifically, CS educators have adopted the practice of pair-programming for the classroom (Porter et al., 2013; Salleh et al., 2011). Our collaborative tutoring system, Collab-ChiQat Tutor, situates students as pair-programmers as they work to solve coding problems with the aid of the computer tutor. With respect to the spectrum of means to structure collaborative activity, we designed two versions of the system offer differing levels of collaboration feedback (Harsley et al., 2016).The *semistructured* system provides visual feedback on group and individual performance while the unstructured system does not. This study outlines the results of a comparative study of system use in an introductory undergraduate CS course and answers the question of how feedback structuring affect learning and collaborative interaction.

Motivating work

Though the historic focus of ITS development has been toward one-on-one tutoring, in more recent years, several one-on-one tutoring systems have been extended to support collaborative learning (Magnisalis, Demetriadis, & Karakostas, 2011; Olsen, Aleven, & Rummel, 2015). ITS researchers and developers are motivated by the noted benefits of collaborative learning as documented in CSCL literature. These include learning for transfer and learning gains that exceed the best of individual learners (Kaptelinin, 1999). However, it is well accepted that effective collaboration and student learning does not follow simply by placing students in groups. Instead, broadly, much CSCL research has examined how collaborative activities can be designed and structured in order to facilitate the most desirable outcomes. One such method is feedback via the display of group and individual performance. Individual and group participation visualization, peer feedback visualization, and the overall symmetry of participation have led to higher signs of engagement and improved performance (Janssen et al., 2007; Phielix et al., 2011).

One of Collab-ChiQat Tutor's primary goal is to help battle the problem of student retention that has plagued the CS discipline (Porter et al., 2013). This issue especially effects underrepresented students in the discipline including women and minorities (Washington et al., 2015). Collab-ChiQat Tutor's modules provide tutoring for CS data structures and algorithms which are significant hurdles for students that also impede retention efforts (Green et al., 2015).

Undoubtedly, both the CSCL and ITS community shape the current context of technology-enhanced learning. CSCL shows that students learn effectively in groups given proper mechanisms and activities. Moreover, it has established that computational environments can support the structuring of this collaboration. On the other hand, ITSs offer adaptive learner support that models an individual user, the learning domain, and the tutoring strategy. We reconceptualized our tutoring system with these bodies of research as foundation along with the CS model of pair programming. Notably, we recognize that the role of the tutor in structuring collaboration can widely range from limited structure with no collaboration feedback to high structuring with role definitions, group formation, and even timing of communication (Harsley, 2014). Thus, this study contrasts two methods of tutor collaboration structuring.

Methods

The *unstructured* interface consisted of four components; 1) textual problem 2) graphical problem representation 3) tutor feedback area and 4) coding interface. The *semistructured* version added a fifth panel, the collaboration panel, which provided graphical representation of the pair's individual and group performance (see Figure 1). The design of the collaboration panel was intended to promote self and group reflection, role-switching, and knowledge generative activities. We have reported more on the system architecture in prior work (Harsley et al., 2016). Seven problems were presented to students in increasing order of difficulty.

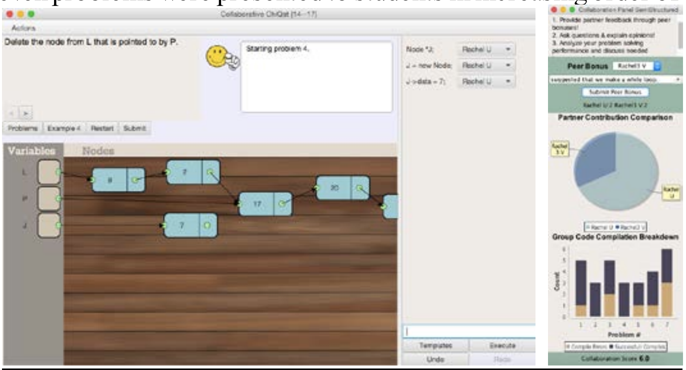

Figure 1. Main tutoring system interface (left) and *semistructured* condition collaboration panel(right).

This study was conducted in an introductory computer science course for undergraduates at a large public university. It consisted of a one-time intervention in which student used the tutoring system during a single lab session. 21 pairs participated in the study, with 41 students electing to share their data. Students chose their own partners and pairs were randomly assigned to a condition. In both conditions, students individually completed timed, identical tests. The test covered key concepts regarding the tutoring topic of CS linked lists. After completion of the post-test, students also took a brief survey regarding their overall experience with the system and general dispositions in regards to working with pairs. In both cases, students used the system for a total of 40 minutes. Seven coding problems were available for students to solve sequentially.

The tutoring system exhaustively logged student interaction with the systems. This included time-stamped traces of student clicks, keyboard events, the time to start a problem, the number of undo operations, and even number of lines coded before switching *driver,* and tutor feedback allowing later recreation of the students' activity on a fine grained level. Moreover, we collected audio recordings of each pair as they worked with the system. The system used a real-time estimate of student dialogue user automatic speech recognition. However, the recorded audio data was later transcribed manually post-intervention. We generated transcription-based features including counts of domain-related words and number of utterances. Moreover, we automatically labelled each transcribed utterance as either 1)question 2)command 3)prompt or 4)assertion following Walker and Whitaker's utterance based control rules (Walker & Whittaker, 1990). These labels were then used to track shifts in linguistically-based initiative. Initiative occurs when a speaker contributes new content (including questions) to the conversation that are not in response to the other participant.

After establishing our feature set, we used multiple linear regression to model post-test scores. A model was created for each feature along with a student's pre-test score as a co-variate. Our goal in this analysis was to establish which features were significant correlates to student learning. We followed the linear regression analysis with unpaired t-tests between every feature as compared between conditions. For example, we compared the time to start problem one in the *unstructured* condition versus the *semistructured* condition. This analysis would allow us to establish how different methods of structuring collaboration guidance affect collaboration and overall system interaction. Finally, we examined the student responses to survey questions to see differences in perception of collaboration.

Findings

Learning

We begin our contrastive analysis by comparing the learning gains of students measured as the difference between pre and post test scores. In both conditions we found a significant difference in learning gain ($p<.01$) establishing that students learned from using Collab-ChiQat Tutor. Further, there was not a significant difference in pre-test scores or learning gains between conditions. The learning gains are shown in Table 1.

Table 1: Student learning gains.

Condition	N	Pre-test		Post-test		Gain	
		μ	σ	μ	σ	μ	σ
Unstructured	22	.46	.20	.58	.21	.12	.19
Semistructured	19	.57	.23	.67	.24	.11	.28

Symmetry, planning, and pair programming perception

After establishing the effect of both conditions on student learning, linear regression analysis revealed that both symmetry was a significant correlate to learning. Namely, the number of times a student took dialogue initiative was significantly positively correlated to learning in both conditions ($p < .05$). Intuitively, as students work to solve the problem together, the initiative should shift between students. However, in the *semistructured* condition, the amount of times a partner took initiative was negatively significantly correlated to learning. This implies that the *semistructured* condition did not promote a balanced, or symmetric relationship. As expected, learning occurred as a student took initiative, however, as their partner took initiative, learning suffered. This finding was confirmed with analysis of student turn taking behavior while writing code. In the *semistructured* condition, the difference in coding turns between partners is significantly positively correlated to learning ($p = 0.04$, Adjusted-$R^2 = 0.73$). This means that as students had a large difference in coding taking turns, or one student dominated, learning improved.

Features pertaining to planning also played a key role in modelling learning. The time to start a problem is the time spent between when the problem is introduced and when students submit their first line of code. The time to start problems four through seven was positively significantly correlated to learning in the unstructured condition ($p < .05$). The importance of time before coding is intuitive as well as its approximation for planning time. Moreover, given our audio analysis, this time was most often spent discussing the meaning of the problem and proposing a solution approach. Notably, there was also a significant difference between *unstructured* and *semistructured* conditions in the time to start problems four and five ($p < .05$). As the problems increased in difficulty, the majority of students did not complete problems six and seven, thus we find no significant difference between conditions in these problems. However, these findings suggest that, unlike the students in the *unstructured* condition, students in the *semistructured* condition did not engage in planning as problem difficulty increased.

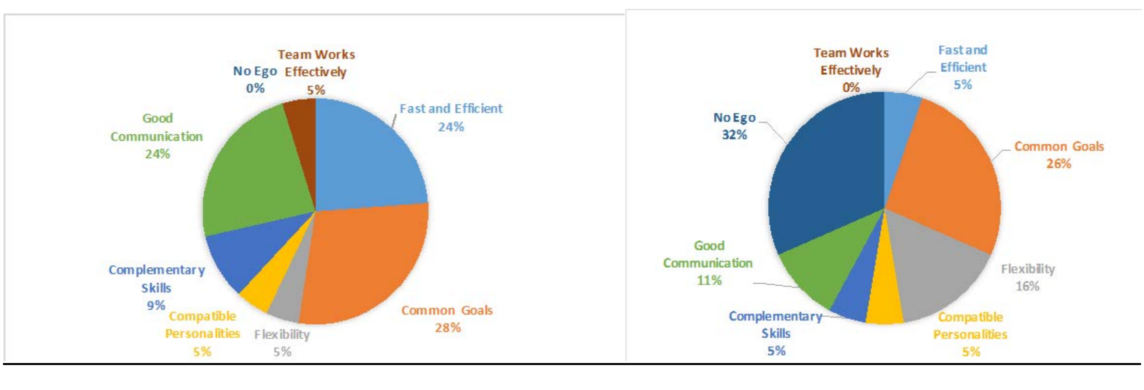

Figure 2. *Unstructured* (left) and *semistructured* (right) most important attribute of a pair programming team.

Lastly, survey results from students revealed that roughly the same proportion of students found the system helpful and interesting across conditions. However, students in each condition had distinctly differing perspectives on the attributes of a good pair programming team. Students in the *unstructured* condition ranked "Common Goals", "Good Communication", and "Fast and Efficient" to be the top three attributes. Contrastingly, students in the *semistructured* condition ranked "No Ego", "Common Goals", and "Flexibility" as top attributes. Notably, the *semistructured* attributes place more importance on individual acts that may be perceived as deference to their partner. On the other hand, *unstructured* users focus on group traits. A visualization of student responses is given in Figure 2. This same trend persists in student's free response to top attributes. Students in the *semistructured* condition used words such as "understanding" and "confidence" which do not appear at all or as frequently in *unstructured* student responses. Instead, the higher frequency of *unstructured* responses such as "respect" and "trust" allude to more group symmetry.

Conclusion

In this paper, we presented our redesign of a traditional one-on-one tutoring system to facilitate pair collaboration. The tutoring domain is Computer Science (CS) Education and the collaborative system takes advantage of the CS paradigm, pair programming. The paper presented our comparative analysis of two versions of the collaborative system which offer varying degrees of collaboration feedback to the pairs. We collected extensive logs of system use as well as audio recordings of pairs. We found that students in both conditions experienced significant learning gains. Moreover, shifts in dialogue initiative where significantly positively correlated to learning gains in both conditions. However, students provided with additional collaboration feedback in the *semistructured* condition, showed less signs of planning and symmetry as demonstrated through their time spent discussing the problem before coding and coding turn taking behavior.

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Examining Positive and Negative Interdependence in an Elementary School CSCL Setting

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Abstract: Social interdependence is a key concept in CSCL research. However, investigations of students' positive and negative interdependence during collaborative activities have often relied on self-report, rather than dialogue analysis. Bringing together politeness and social interdependence theory, we assessed *dialogue indicators* of positive and negative interdependence from behavioral data (namely, face-saving and face-threatening dialogue moves) and compared the results with those of self-report scales. We analyzed a data set of 30 elementary students learning fractions with an intelligent tutoring system (ITS). Our initial analyses focus on the link between use of language that is face-saving (e.g., marking identity with statements such as "we are great") or face-threatening (e.g., insulting), and students' preferences to collaborate and compete. We found only non-significant correlations between these two broad categories, but found significant correlations between dialogue indicators, such as the use of identity markers and joking, that suggest directions for subsequent studies.

Introduction

A major predictor of how students are learning collaboratively is the dialogue that occurs within a group. Often dialogues are analyzed for the cognitive aspects of the collaboration while ignoring the social interactions that are occurring between students. However, in previous studies, in which the social aspects are analyzed, they have been found to play a significant role in the student collaboration (Wang et al., 2008; Ogan, Finkelstein, Walker, Carlson, & Cassell, 2012). In CSCL research, social aspects often address types of interdependence among interacting students. As a key concept of CSCL research, social interdependence describes the relationship between students, which can be either collaboratively or competitively (Johnson & Johnson, 2014). Whereas collaboration belongs to positive interdependence, because the success of interacting students is positively related, competition describes a situation, in which the students' chances to succeed are negatively related (Johnson & Johnson, 2014). Investigations of social interdependence have often been limited to investigating positive interdependence between students without investigating the impact of negative interdependence on student learning. In our paper, we propose to analyze the dialogue between students to understand how both positive and negative interdependence correlate with the students' self-reported approach to group learning and their learning gains.

Positive and negative interdependence are defined within the social interdependence theory, which provides a lens for exploring the social dimension of student collaboration (Johnson & Johnson, 2014). To achieve positive interdependence within a group, the collaborative task must be structured in a way that only allows students to succeed if all group members succeed (Johnson & Johnson, 2014). However, students do not always approach the task in a collaborative manner and may instead view it as a competition. Competition can lead to negative interdependence between students. In this state the success of one student depends on the failure of another (Johnson & Johnson, 2014). Thus, negative interdependence will likely inhibit collaborative behaviors.

Within computer-supported collaborative learning (CSCL) research the impact (or possibility) of negative interdependence often has been neglected. Additionally, learning environments are assumed to foster positive interdependence among students without checking if positive interdependence was indeed achieved (Olsen, Aleven, & Rummel, 2016). More generally, within the field of CSCL, there has been little research on *behavioral indicators* of positive and, in particular, negative interdependence and how it relates to learning. Most studies that measure interdependence rely on students' self-reports about their behavior during the learning phase (Myake & Kirschner, 2014) or their preferences for working collaboratively or competitively (Johnson & Norem-Hebeisen, 1979). However, as self-reports do not necessarily reflect the actual interactions that occurred during the learning activity, exploring additional indicators of positive and negative interdependence by studying the student dialogue may offer new theoretical insights into the process of collaborative learning.

Politeness theory (Brown & Levinson, 1987) is potentially highly valuable for extending research on positive and negative interdependence as both forms of interdependence often reveal themselves through the language and word choice that students use in their communication with each other. Politeness theory stipulates that individuals have a need of being appreciated as a valued member of a group (Brown & Levinson, 1987). To achieve this, individuals avoid excluding statements and actively respect or 'save' another person's face by using politeness strategies. Based on politeness theory, one could expect that collaborating students often attempt to save each other's face. For instance, when students use words that indicate they are part of the group – identity markers, such as 'we' – the face of other group members may be enhanced because they see themselves as respected within the group. If there is positive interdependence among students, the importance of face-saving behavior potentially increases since the students need (or want) to succeed as a group. On the other hand, if a student insults the abilities of another student then there is a threat to that student's face, and an active dissociation from the group identity could be assumed. Such face-threatening behavior may result from negative interdependence among students because competition goes along with discrediting the 'opponent' to strengthen one's own position. By analyzing the face-saving and face-threatening behavior that are used within the student dialogue, politeness theory can help to analyze social interdependence within the dialogue. Specifically, face-saving strategies (e.g., using an identity marker, making jokes, laughing) can be associated with positive interdependence whereas face-threatening strategies (e.g., insulting, swearing, disagreement) can be associated with negative interdependence.

In this paper, we analyze the dialogue data collected during elementary school students' use of a collaborative intelligent tutoring system (ITS) (Olsen, Aleven, & Rummel, 2016) to explore how students' self-reported preferences for working collaboratively or competitively are associated with dialogue strategies used during learning that focus on face-saving and face-threatening strategies. By bringing together politeness and social interdependence theory, we developed and tested indicators of positive and negative interdependence with students' dialogue data and compared it with self-reported scales of students' collaborative and competitive preferences. This explorative research extends existing studies of social interdependence within CSCL by investigating students' communication directly and comparing it with self-reported data, which is typically used. We hypothesize that face-saving strategies positively correlate with collaborative preferences and face-threatening strategies positively correlate with competitive preferences.

Methods

For our analysis, we used dialogue transcripts of $N = 30$ collaborating elementary students (15 dyads). The data was from a study investigating 4th and 5th-grade students who worked collaboratively with an ITS (Olsen, Aleven, & Rummel, 2016). The learning phase took place on three 45-minute days with the students' knowledge measured at pretest and posttest on two additional days. Within our analysis, we only included students who completed all learning phases with the same partner. The students either worked on a conceptually or procedurally oriented tutor that focused on naming, making, equivalent, least common denominator, as well as comparing, adding, and subtracting fractions. During the time with the ITS, students sat next to each other and thus were able to communicate directly. The tutors supported synchronous, networked collaboration through embedded collaboration scripts, in which collaborating students had a shared view of the problem state with different actions and information (task and resource interdependence) available on each of their computers. The scripts were designed to support positive interdependence through a distribution of responsibility. For instance, students had some actions that only they (and not their partner) could take. Students therefore needed to collaborate since they did not have access to all necessary information and actions to solve the problem successfully on their own. However, we do not certainly know if the scripts stimulated positive interdependence among the students.

Self-reported preferences for collaboration and competition

To measure students' preferences for working collaboratively or competitively, we used two scales developed and tested by Johnson and Norem-Hebeisen (1979). In these scales, indicators of collaborative preferences include a tendency to help other students, to share ideas and materials, or to consider supportive behavior. In contrast, students with competitive preferences prefer to 'be better than others' or to 'challenge who is best' (see Johnson & Norem-Hebeisen, 1979 for more information). The collaboration scale (i.e., cooperation in Johnson & Norem-Hebeisen, 1979) consisted of seven questions, whereas the competition scale consisted of eight questions, which were measured on a seven-point Likert scale. All students completed both scales.

Examining politeness strategies and face attacks from dialogue

We analyzed transcripts of the students' dialogue for all three days the students worked with the ITS. Based on politeness theory, we identified several *face-saving behaviors* (i.e., identity markers; compliments; agreements; encouraging participation; joking statements; laughing) and *face-threatening behavior* (i.e., insulting; disagreement; preventing participation; swearing). Within the students' dialogues, each of the statements was coded for these behavioral codes, and multiple codes could be applied to each statement. For instance, a single statement could include laughing, identity marker as well as insults. After coding the transcripts of the first day, we tested the inter-rater-reliability to decide if coding with all categories would be suitable. Because Kappa statistics was low for the most behavioral codes, we coded the subsequent days with only the three variables for face-saving and –threatening behavior that had the best Kappa statistics. These categories included: *identity marker, laughing, joking statement, insulting, disagreement*, and *swearing* (see Table 1 for the Kappa statistic). In the following, we briefly explain the categories we used for our analysis of the students' dialogues. For save-saving behavior, we concentrated on *identity makers*, *laugh as a reaction* and *joking statements*. *Identity markers* include the use of words like 'we' which highlight group identity. If students *laugh as a reaction*, they might foster group cohesion or have a close relationship, in which positive interdependence is naturally given. In addition, contributing *joking statements* to cause amusement or laughter can increase (or indicate) group cohesion. For face-threatening behavior, we focused on *insults*, *disagreement* and *swearing*. In contrast to face-saving behaviors, *insulting* someone (e.g., 'you suck') might attack cohesion between students. The same may be true for *swearing* and *disagreeing*, whereas *disagreement* also might express constructive criticism that contributes to a collaborative approach to solving the problem. However, politeness theory defines the expression of disagreement as well as insulting and swearing as a rude behavior as it is attacking the another person's face.

Findings

We correlated the face-saving and -threatening behavior, the collaboration and competition scales by Johnson and Norem-Hebeisen (1979), and the students' learning gains from pre- and posttest (see Table 1). We did not find a significant correlation between any of the variables and learning gains. However, there was a significant, negative correlation between students' preferences to collaborate and their preferences to compete (r_S = -.41, $p < .01$). Within the behavioral indicators, we found a significant correlation between the use of identity markers and joking statements (r_S = .61, $p < .01$) and between showing disagreement and insulting a partner (r_S = .67, $p < .01$). We found no significant correlations between any of the remaining variables. Nevertheless, as highlighted in *Table 1*, we found – even if not significant – moderate negative correlations for all face-attacking variables with preferences to collaborate, as well as moderate positive correlations between these variables and preferences to compete.

Table 1: Spearman's rho coefficient and Kappa statistics

		Kappa	1	2	3	4	5	6	7	8
1.	Learning Gain (Pre-Post)									
2.	Competition Scale		-.24							
3.	Collaboration Scale		.14	**-.41***						
4.	Identity Marker	.65	-.20	.23	-.16					
5.	Laughing as Reaction	.85	-.07	-.06	.17	.16				
6.	Joking Statement	.54	-.08	.32	-.11	**.61***	.26			
7.	Insulting a Person	.45	-.07	**-.22**	**.21**	.19	-.11	.34		
8.	Disagreement	.41	.02	**-.19**	**.13**	.22	-.06	.24	**.67***	
9.	Swearing	.57	.19	**-.23**	**.31**	.10	.33	.35	.30	.35

Discussion

Our explorative analyses examined the link between face-saving statements (e.g. using identity markers, making jokes, laughing) and face-threatening statements (e.g. insulting, swearing, disagreement) and students' preferences to collaborate or compete. By bringing together politeness and social interdependence theory, we developed and tested indicators of face-saving and -threatening actions to compare coded dialogue data with self-reported scales. We hypothesized that face-saving strategies positively correlate with collaborative preferences and face-threatening acts positively correlate with competitive preferences. Although we found a negative correlation between the competition and collaboration preference scales indicating divergent validity, the data provides no evidence for our hypotheses regarding the alignment of the face-saving and face-threatening strategies with the self-reported scales. Interestingly, there was a significant positive correlation between the use of identity makers and joking statements. Thus, students, who make more jokes also tend to use more group identity markers such as "we" or "us". One could argue that joking occurs especially when students have already established a good relationship and thus feel more group identity and social cohesion, which in turn could be represented by the use of identity markers. Conversely, if students do not have a common ground or a close relationship, as could be indicated by a low frequency of identity markers, they likely do not make jokes. In addition, we found a significant positive correlation between insulting the partner and showing disagreement, which is of particular interest for research on younger students. It could mean that elementary school students tend to express disagreement or a conflicting point of view by using face-threatening behavior such as insulting.

Surprisingly, we found positive, even though non-significant correlations for face-threatening dialogue behaviors and collaborative preferences of the students and, conversely, negative, non-significant correlations between these same dialogue behaviors and competitive preferences. This finding aligns with results of Ogan et al. (2012), who showed that insulting (or rudeness) can be an expression of rapport between students and may lead to higher learning gains. Thus, one could argue that face-threatening behavior indicates collaboration (or at least, a desire or tendency to collaborate). Students who want to collaborate may not have the abilities to do it appropriately, especially in this young age group. This explanation also is consistent with the fact that insulting correlates with disagreement, as younger students might not know how to disagree with each other's ideas without being rude and using insults. For subsequent analyses, we may have to rethink our hypotheses.

However, using politeness theory to investigate student dialogue provides some challenges. A major hurdle in analyzing student dialogue based on politeness theory is understanding how a certain message was intended to be interpreted and how it indeed was interpreted by the addressed student. An insult, for instance, can either be a face-threatening behavior with the intention to harm someone, or it can express friendship between students, whose relationship is strong enough to endure rudeness. Further studies may focus on more qualitative analyses of dialogue to figure out in more detail how students (co-)construct their relationship within this CSCL setting. Continuing analyses with more qualitative methods could lead to a deeper understanding of how social interdependence manifests itself in dialogue. Furthermore, in learning environments that aim to foster interdependence among students, one could expect that the learning outcomes (or success) of students in the same team are positively related. To analyze in more detail how students treat each other depending on their preferences to collaborate or compete, the form of interdependence within the learning situations, and the effects on their learning outcome could be an interesting direction for future research in CSCL.

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Transgressing Ideologies of Collaborative Learning and Working Spaces

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Abstract: This paper offers a theoretical contribution to CSCL by foregrounding the notion of place as elaborated in humanistic and cultural geography (Creswell, 1996), where place is defined by ideology and practices that produce, monitor and reproduce its boundaries. Examining the notion of place as both an element in CSCL tool design and a level of analysis for CSCL (Stahl, 2012), we discuss its role in the emergent design and development of a CSCL application for teachers, university students and researchers. The discussion in this paper serves as a first step in articulating how (1) CSCL tools can transgress and thus question official learning and working places and (2) how transgression can foster re-ordering of places and their practices.

Introduction

The following paper offers a theoretical discussion surrounding the iterative design and development process of a computer-supported collaborative learning and teaching application for educators. It makes a contribution towards building a theory for CSCL (Stahl, 2004) by adding an additional "plane" or unit of analysis to those that have been traditionally examined in the context of CSCL (Stahl, 2012). In particular, we are theorizing the design of CSCL for its less explored capacity to transgress, i.e., cross boundaries and ideologies of physical places and their practices. To do that, we foreground the concept of place as elaborated in humanistic and cultural geography (Cresswell, 1996; Tuan, 2001). These conceptions stress place not only as a deeply complex human element, but also as "the basis for human interaction" (Cresswell, 2015). According to Cresswell (1996), place is,

> produced by practice that adheres to (ideological) beliefs about what is the appropriate thing to do. But place reproduces the beliefs that produce it in a way that makes them appear natural, self-evident, and commonsense. We are silent in libraries, and by being silent in libraries we contribute to the continuation of silence. Thus places are active forces in the reproduction of norms—in the definition of appropriate practice. Place constitutes our beliefs about what is appropriate as much as it is constituted by them.

Thus, place as an additional level of analysis or theoretical lens, allows us to examine and question established (normalized) structures that rely on collaboration. Our thinking behind the design of a software application that relies on collaboration between university and school provides the background for this discussion. Moreover, we emphasize and theorize place not only as a unit of analysis, but also simultaneously as an important design element of CSCL tools that seeks to link structurally and ideologically separate places. In our case, over the years of development, we have discovered that the iterative design involving researchers, programmers, teachers and students, pushed our thinking about technology integration, design, and collaborative learning across places and their designated practices. As a first step, instantiated by this paper, we are articulating the design process and thinking involved in transgressing places of learning and working.

Significance

Notions of place and relationships between places where learning and collaboration occurs tend to be less visible aspects of CSCL tool design. Perhaps, even less visible are the links between online environments and places such as schools or universities. Again, the concept of place used here is not simply defined by an architectural structure or location, rather by practices that engage with and produce certain values (i.e., ideologies) through them. Our goal is to apply the notion of place as a "way of seeing" (Cresswell, 2015) two related places and their practices (i.e., places and their ideologies), namely teacher preparation programs at universities and schools. We suggest that such a move can open up and influence the design process when examined in terms of both existing and absent connections between places. In our case, the design of our software application has been informed by places and their practices deemed appropriate for learning and those places typically associated with the notion of work. Ultimately, for us, this division of learning and working places represented a recurring problem hindering the successful use of the software (see next section). It focused our attention on distributed learning across time and place and the need for ongoing access to collaborative spaces that transgress traditional understandings of learning and working. Consequently, we started conceptualizing collaboration and design at the level of place, i.e., between ideologies associated with institutions that engage in training and working. Such a theoretical move parallels views of learning as a socially and culturally distributed process amongst individuals, practices, tools and environments, as distributed expertise and cognition (Barron & Bell, 2016; Brown et al., 1993; Hutchins, 1995a,b; Nasir, Roesebery, Warren & Lee, 2006; Rogoff, 1995; Pea, 1993; Stahl, Koschman & Suthers, 2014), while highlighting ideological dimensions of the connection and interaction between places. Hence, the design of our CSCL tool involves thinking about what defines places, about established beliefs and practices that give and maintain their meaning, about their boundaries and their transgression.

The CSCL application

Over the last 6 years we developed a software application, *ibestt* (Integrating Behavior Support and Team Technology), to support educators in elementary and middle school settings. *ibestt* was built to assist teachers in collaboratively addressing challenging behaviors in their classrooms. Given inherent complexities within classroom environments, the software design had to account for both rigor and flexibility within the online and offline environments it bridges. Although, *ibestt* helped educators implement behavior supports to some extent, teachers and school teams were often not successful, which ultimately lead us to a design that grapples with the notion of place. Our analysis of *ibestt* use over the past several years is consistent with decades of findings in the school-based behavior intervention research literature: many educators struggle with the complexity of the support process and the applied behavior expertise that is required to provide appropriate and positive behavior interventions. To address these challenges, a new iteration of the application includes asynchronous online coaching interactions between team members and between behavior experts and novices. Simultaneously, we began to hypothesize that team success is influenced by the separation of training, learning and working practices in the context of teacher education, disrupting expertise development and collaborations. This led us to consider place as a contributing element in collaborative learning. As a result, we are presently working on using *ibestt* to connect university teacher-preparation programs with school districts and their communities. This place-oriented design will enable *ibestt* to become a tool that accompanies teacher candidates through their education into their work environments, simultaneously bridging ideological and physical boundaries between traditionally separate learning spaces, i.e., between learning, training and work. The emerging software design frames teacher preparation as a non-linear but continuous process, as an apprenticeship, conflating learning places and those associated with professional practice.

Conclusions

We wanted to take a first step to emphasize and articulate place as a design element in CSCL, in particular the design of computer technologies to question places and their practices. There are different reasons for the absence of place in discussions of CSCL. Most of the time it is a matter of a different focus, yet places and their ideologies are often invisible and unquestioned, i.e., they reproduce themselves through the practices that give them meaning (Cresswell, 1996). What makes place a distinct design element worthy of a separate discussion in the context of developing a theory of CSCL (Stahl, 2004) is that it provides a different entry point for discussing higher-level interactions that contribute or hinder learning. Hence we suggest that the interactions or collaborations occur at a level of place and its ideology, in our example, between university teacher education programs and schools. Places are defined by practices, their reinforcement and reproduction. Hence connections between places link and transgress practices and ideologies. What is of particular interest to us are the interactions and thinking that is made possible by CSCL software, between places in which learning and working takes place. The design process was informed by the interactions between researchers, designers and practicing teachers, i.e., interactions between educators and their particular places. These multiple-year long exchanges, data analysis, and iterative design revisions lead us to the current conclusion that places and their boundaries impact learning and working, that the attention to and transgression of these boundaries can be an essential part of the design and solution process.

What we suggest here is that there is value in attending to place as an element that shapes the boundaries between definitions of learning and working. The often presumed independence of spatial, local or sociopolitical constraints associated with CSCL practices and online environments contribute further to the obscurity of place as an ideological construct. As we are developing the application, we are starting to conceptualize the relationships between learning, working and place. Undoubtedly, CSCL is not only about sharing knowledge and collaborative practices (Stahl & Hesse, 2009), but also about questioning, reconstructing and sharing places where learning and work takes place. Consequently, the developing software design discussed here is not only an attempt to share but to shape infrastructure of these spaces. Connections between places traditionally associated with education involve not only close attention to social aspects of learning and interaction, but also to politics and ideology of place as a design element.

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A Preliminary Study of University Students' Collaborative Learning Behavior Patterns in the Context of Online Argumentation Learning Activities: The Role of Idea-Centered Collaborative Argumentation Instruction

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Abstract: Learners have more and more opportunities to encounter a variety of socio-scientific issues (SSIs) and they may have difficulties in collaborative argumentation on SSIs. Knowledge building is a theory about idea-centered collaborative knowledge innovation and creation. The application of idea-centered collaboration practice as emphasized in knowledge building may be helpful for facilitating students' collaborative argumentation. To examine the perspective above, this study attempted to integrate idea-centered collaboration into argumentation practice. The participants were 48 university students and were randomly divided into experimental and control group (n=24 for both groups). The control group only received argumentation instruction, while the experimental group received explicit idea-centered collaborative argumentation (CA) instruction. This study found that two groups of students revealed different collaborative learning behavior patterns. It is also noted that the students in the experimental group benefited more in collaborative argumentation from the proper adaption of knowledge building and explicit idea-centered collaborative argumentation instruction.

Introduction

In the knowledge-based societies, learners have more and more opportunities to encounter a variety of social dilemmas coming with rapid development in science and technologies. These social dilemmas are often termed "Socio-scientific issues (SSIs)" which are controversial social issues that are generally ill-structured, open-ended authentic problems which have multiple solutions (Sadler, 2004; Sadler & Zeidler, 2005). When trying to find better solutions, learners may need to be involved in SSI-based argumentation learning activities in order to find better ideas reaching consensuses and achieve compromise solutions (Walker & Zeidler, 2007).

Beretier and Scardamalia (2003) distinguished between "belief mode" and "design mode" in work with ideas. If activities that are related to ideas evaluating, questioning, accepting, or rejecting knowledge claims, they belong to "belief mode"; whereas the activities have broader range that are related to knowledge production, improvement, searching for better ideas, they belong to "design mode" (Beretier and Scardamalia, 2014). It should be noticed that SSI-based argumentation sometimes falls in the situation of win-or-lose argumentation which are not in collaborative manner or related to idea refinement. In other words, SSI-based argumentation is often implemented as the "belief mode" activity. To address the aforementioned issues, argumentation practice emphasizing idea-centered collaboration that is adapted from knowledge building could be promising. Knowledge building emphasizes the importance of creating knowledge jointly in a community, and it describes what a community of learners needs to accomplish in order to improve ideas and create knowledge (Scardamalia & Bereiter, 1994; 2003; 2006). The adaption of idea-centered collaborative argumentation regarding a SSI may turn the win-or-lose situations of SSI-based argumentation into more community knowledge refinement situations. That is to say, turning the "belief mode" argumentation to "design mode" one. Therefore, in the study, idea-centered collaboration argumentation learning activities were designed and implemented.

Moreover, as revealed in previous research, students often have limited argumentation skills. For example, they often have difficulties in generating counter-arguments due to the lack of knowledge of different perspectives (Leitao, 2003). To improve students' argumentation skills, previous research has suggested the use of explicit instruction in argumentation (e.g., Andriessen, 2006). However, relevant studies are still not available in SSI-based collaborative argumentation contexts. Therefore, this study also examined the effectiveness of explicit instruction that focuses on both collaboration and argumentation skills in students' SSI-based argumentation. To sum up, this study is one of the initial attempts trying to exam the role of explicit idea-centered collaboration argumentation in students' argumentation practice. The research questions are as follows:

1. When implementing KB-based SSI argumentation learning activities, how these two groups of students

with different instructions (idea-centered collaborative argumentation instruction vs. argumentation instruction only) differ in terms of their knowledge building behavior patterns?

2. When implementing KB-based SSI argumentation learning activities, how these two groups of students with different instructions (idea-centered collaborative argumentation instruction vs. argumentation instruction only) differ in terms of collaborative argumentation behavior patterns?

Methods

Participants and learning contexts

The participants in this study were two classes of 48 students (14 men and 34 women, mean age 21 ± 3 years) in a university in southern Taiwan. They were students from different departments and institutes who took the same academic course (from March to June 2016) called "Science, Technology and Society". The study started from March to May in 2016. All the participants were taught by the same teacher who had been using knowledge building pedagogy and Knowledge Forum in the classroom for over one year. Participants from the two classes were randomly divided into two groups (Experimental Group n=24; Control Group n=24). In each group, 4 participants were also randomly assigned into a small group for knowledge building-based argumentation learning activities. There were 6 small groups in the experimental and the control group respectively.

Idea-centered collaborative argumentation instruction and Knowledge Forum

There were three phases in this study. In the first phase, all participants were required to read articles or listen to academic speeches about different SSIs topics, such as energy, climate, and environment issues. In this phase, the participant teacher also gave a mini lesson of collaborative knowledge innovation and creation (based on the knowledge building core principles) to the participants. Then the students were given a SSI topic for discussion in Knowledge Forum (KF) for four weeks. To ensure participants' familiarity and the quality of discourses in Knowledge Forum, further in-class discussions and feedbacks were given at the end of phase 1.

In the second phase, both groups received a two-week instruction in class. The control group received argumentation instruction including the concept of arguments, counter arguments, and how to do rebuttals. In the instruction phase, a mini lesson of argumentation was given to the participants. The participant teacher gave some questions to the participants to discuss in class (e.g. Why argumentation skill is important for you? What is the result of argumentation?). Then, the participant teacher taught them the definition of argumentation and its step by step skills. Finally, SSIs topics that the participants have learned were used in argumentation practices in class. For the experimental group, besides the aforementioned argumentation instruction, they also received the instruction focusing on the idea-centered collaboration argumentation. They learned the phrases which showing idea-centered collaboration and practice saying them in the argumentation practice (e.g. I am looking forward to seeing my group member's opinion. I think it is a good idea. I think the idea can be listed into our consensus). The purpose of idea-centered collaborative argumentation instruction was to help the group members have deeper understanding on the topic and reach consensus at the end. (Sadler, 2011). The students in the experimental group learned how to cooperate with other group members in argumentation, how to conduct collaborative argumentation like scientists do. They especially focused on how to make arguments collaboratively. They were also encouraged to provide evidence and justify them within their groups.

In the final phase, a highly controversial SSI topic in Taiwan, "There are many ways to solve the power shortage issue in Taiwan, such as thermal power, hydroelectric, nuclear power. What could be the better solution by using these different approaches?" was given to the two groups for argumentation for four weeks. All participants were required to discuss the topic anonymously in class and asynchronously in KF. The control group used the normal openers provided in Knowledge Forum, while openers related to collaborative argumentation were also provided to the students in experimental groups additionally. At the end of this phase, each group needed to synthesize their ideas and finish a group report.

In traditional classrooms, students may feel shy or frustrated when they express their ideas in public. In particular, they may not propose their arguments because they are afraid of losing face or may fight against with others especially in the face to face interaction environment (e.g. in the classroom) (Andriessen, 2006). Researchers suggest that learners may also need technology helping them to work together when they are involved in collaborative argumentation learning activities (Clark et. al., 2010; Noroozi et. al., 2012). In this study, Knowledge Forum is adopted to promote learning equity and improve their argumentation performances. Scardamalia (2004) described that the KF scaffolds help students clarify and organize the writing of their concepts in a note and help students focus on particular aspects of the knowledge-building process when exchanging information, working in ways similar to a scientific group. In this study, several KB principles were enacted. For example, the ideas are real and authentic (Real ideas and authentic problems), students continuingly refine, generalize and synthesize the ideas (Rise above), every group member possesses equal right and take equivalent responsibility for advancing community knowledge (Collective responsibility for community knowledge).

Data collection and analysis

The primary data sources were students' online entries (notes) in Knowledge Forum in the final phase. Students posted notes whenever they had free time outside the classroom. The students in both groups were encouraged to post notes with openers. In the study, there were 327 entries and 425 entries in the control group and experimental group respectively.

In this study, two coding schemes, the knowledge building coding scheme and the collaborative argumentation scheme were used to analyze students' entries in both the groups. The knowledge building coding scheme includes "My idea (KF1)", "I need to understand (KF2)", "New information (KF3)", "This idea cannot explain (KF4)", "A better idea (KF5)", "Putting our knowledge together (KF6)". This coding scheme is exactly the same as the openers in Knowledge Forum. The collaborative argumentation coding scheme is adopted from McAlister, Ravenscroft and Scanlon (2004), it includes "Inform (CA1)", "Question (CA2)", "Challenge (CA3)", "Reason (CA4)", "Support (CA5)", and "Others (CA6)". All the entries were arranged according to the two coding schemes respectively and were given appropriate codes by the authors separately. The authors then discussed the codes regularly. If the authors had different opinions on the codes, they discussed the differences until they had reached the consensus. In other words, each students' note was given both a knowledge building code and a collaborative argumentation code. After the qualitative coding, Lag Sequential Analysis (LSA) was adopted to analyze the sequential correlations between chronologically ordered behaviors including the group knowledge building behavioral patterns and collaborative argumentation behavioral patterns. The method was utilized to visualize the sequential correlations between chronologically ordered behaviors (Bakeman & Gottman, 1997; Hou, 2012; Hou & Wu, 2011). The inter-coder reliability is greater than 0.8. Authors discussed and reached consensus if any disagreements occurred.

Results and discussion

Figure 1 shows the results derived from the Lag Sequential Analysis of students' knowledge building behavioral patterns (see Figure 1, Left). In the experimental group, "New Information (KF3)" and "This idea cannot explain (KF4)" indicated the significant sequences; "Putting our knowledge together (KF6)" shows significant self-sequence. It seems that when there was new information regarding an idea proposed, the students in the experimental group significantly tended to challenge the idea with new information. Also they significantly tended to synthesize their ideas together frequently. However, no significant sequences were found in the control group. The results indicate that the implementation of collaborative argumentation instruction in the experimental group may improve their ideas and help them synthesize their ideas regarding a SSI.

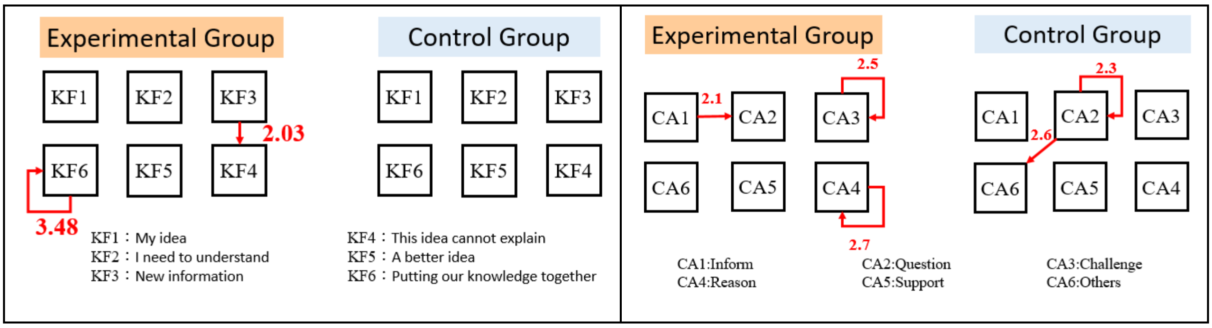

Figure 1. Knowledge building behavioral Patterns between the two groups (Left) and Collaborative argumentation behavioral Patterns between the two groups (Right).

Figure 1 also shows the results derived from the LSA of collaborative argumentation behavioral patterns in the two groups (see Figure 1, Right). Both the groups revealed significant collaborative argumentation behavioral sequences, but their learning patterns are various. In experimental group, "Inform (CA1)" and "Question (CA2)" indicate the significant sequences, "Challenge (CA3)" and "Reason (CA4)" both show significant self-sequences. It indicates that the students in experimental group tended to elaborate new ideas or arguments after they were proposed. Besides, they also tended to refine their arguments or challenge new arguments, and they tended to reason and synthesize their arguments. It is noted that in the control group, "Question (CA2)" shows significant self-sequence and has significant sequence with "Others (CA6)". However, in the control group, students tended to ask questions again and again, indicating that they might always fail to clarify their arguments. Besides, after asking questions to clarify existing arguments, they also tended to be off-task or lost focus. In sum, the students in the experimental group benefited more from the explicit idea-centered collaborative argumentation instruction in this study in terms of their idea and argument refinement and achieving a synthesized solution regarding a SSI. On the contrary, the control group may not refine their arguments regarding SSI due to their win-or-lose or off-task patterns.

Conclusion

This study was one of the initial attempts to adapt the idea-centered collaboration argumentation regarding a SSI. Both argumentation instruction and explicit idea-centered collaborative argumentation instruction were implemented in this study. By analyzing the students' knowledge building and collaborative argumentation behavioral patterns, the results showed that KB-instruction is useful for improving collaborative argumentation (Scardamalia and Bereiter, 1994). However, the two groups of students revealed different collaborative argumentation and knowledge building behavior patterns. The students in the experimental group benefited more in both their knowledge building and collaborative argumentation learning processes from the proper adoption explicit idea-centered collaboration argumentation instruction in online SSI-based argumentation learning activities. They tended to synthesize their ideas and find the better solution at the end. The findings of this study may provide researchers, educators, designers with a useful basis for improving learners' ability of collaborative argumentation.

Limitations

This study has some limitations within which our findings need to be interpreted carefully. First, the study was a preliminary experiment which may need more careful design. Second, because of the time limit, this study was a short-term experiment conducted with only a small size of population. To generalize the results for larger groups, future studies should have involved more participants.

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Reflective Structuration of Knowledge Building Practices in Grade 5 Science: A Two-Year Design-Based Research

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Abstract: This study was conducted in two Grade 5 classes (A and B) taught by the same teacher in two successive school years. Each year students studied human body systems over a whole school year using Knowledge Forum (KF). Both classes worked with an idea-centered, principle-based framework of knowledge building; students in class B (year 2) particularly engaged in reflective structuration to co-construct structures of inquiry as their work unfolded. Qualitative analyses of rich classroom data elaborated the reflective structuration process in class B. The analyses of student online discourse showed that compared to class A in year 1, class B made more purposeful and sustained contributions to understanding various human body systems and developed more sophisticated explanations.

Introduction

Despite the advances made in understanding the social and cognitive interactions in collaborative inquiry and knowledge building, the field of computer supported collaborative learning (CSCL) still faces the challenge of how to bring sustained inquiry and collaborative knowledge building to classrooms so as to transform educational practices (Stahl & Hesse, 2009; cf. NRC, 2012). Beyond understanding the specific social and cognitive processes of idea development, research on knowledge building and collaborative learning needs a social practices perspective, to incorporate a larger focus on the social practices enacted by students and their teacher to sustain and channel their cognitive and social moves for long-term productivity (Hakkarainen, 2009; Stahl & Hesse, 2009). In real-world knowledge building practices, participants continually build on and advance the knowledge assets of their community by generating and identifying promising ideas and improving the ideas through sustained inquiry and discourse; by formulating deeper problems as solutions are developed; and by assuming leadership and responsibility at the highest levels instead of relying on the leader to tell them what to do (Amar, 2002; Dunbar, 1997; Sawyer, 2007). They do not simply enact repeated procedures but continually create and adapt their social practices as their knowledge is advanced (Knorr Cetina, 2001, Zhang et al., 2009). To address the dynamic nature of social practices for knowledge building in classrooms, a principle-based, as opposed to procedure-based approach to inquiry is needed (Scardamalia, 2002). Drawing upon the Knowledge Building pedagogy (Scardamalia & Bereiter, 2006), a renowned inquiry-based program to cultivate authentic knowledge-creating practices, we explored how students and teachers worked with a set of principles to co-design their classroom practices and chart the unfolding course of inquiry (Zhang et al., 2011). This line of research has led to the discovery of an important socio-epistemic mechanism enabling sustained practices of knowledge building: reflective structuration by which knowledge building communities co-construct, adapt, and use collective structures to guide their collaborative deepening work on ideas (Zhang, 2012).

Different from many other inquiry-based learning programs (e.g. project-based learning) in which students are required to work on predefined tasks/problems using step-by-step procedures and scripts, Knowledge Building adopts an idea-centered and principle-based approach to classroom design. Guided by a set of knowledge building principles (e.g. epistemic agency, authentic problems and real ideas, improvable ideas, collective cognitive responsibility) (Scardamalia, 2002; Zhang et al., 2011), students and their teachers co-construct and reconstruct the flow of inquiry as their work proceeds. A conceptual as well as practical challenge arises pertaining to how the idea-centered, open-ended actions/interactions are translated into coherent, supportive, long-term classroom practices without extensive teacher pre-scripting.

We identify reflective structuration as a potential solution to this challenge, and elaborate this concept based on social practice theories (Giddens, 1984; Sewell, 1992). The key to understanding how knowledge building as a social practice can be possibly sustained lies in the dynamic relationship between human agency and social structures that presuppose each other. Social practices become organized and sustained over time because of their relatively stable structures. Such structures both constrain and enable human agency. Actors appropriate existing structures which are historically formed in their institutional contexts, use the structures to plan and guide their ongoing actions, and reflexively monitor what is going on. The actors' agency is reflected in their capability to reinterpret, modify, reorganize, and recreate the structures, influencing future practices by themselves and by other members (Sewell, 1992). In line with the social practice theories, our empirical analysis of productive knowledge building communities revealed that members engage in dual-level construction driven by their agency: as members contribute content-specific questions and ideas to build knowledge, they co-construct collective structures of knowledge practices to guide and support their collaboration and contribution (Tao et al., 2015, 2016). The collective structures serve as shared frames of knowledge building activities signifying structural properties of inquiry, including the epistemic objects/issues to be investigated as the focus of unfolding strands of practices (epistemic structure) (Knorr Cetina, 2001), productive ways to conduct research and discourse (pragmatic structure), and who should work with whom in what roles (participatory structure) (Zhang, 2012). Students use such co-constructed structures to monitor and regulate their joint inquiry and position their roles and contributions.

Our prior exploratory studies have analyzed how students generated and adapted epistemic and pragmatic structures to guide their knowledge building (Tao et al., 2015, 2016; Zhang et al., 2015). The current study further examines the processes and impacts of reflective structuration more systematically through a two-year design-based study, with students in year 2 engaging in reflective structuration more intentionally to frame/reframe shared areas/objects of inquiry for unfolding inquiry practices. Our research questions ask: How did the teacher and her students implement reflective structuration? Did the reflective structuration design in year 2 leverage sustained knowledge building practices among students? To what extent, and in what ways?

Method

Classroom contexts and designs

This design-based research was carried out in two Grade 5 classrooms (A and B) taught by the same teacher in two school years, with 21 students (10-to-11-year-old) in each year. In both classrooms, students investigated human body systems over a whole school year following Knowledge Building pedagogy supported by Knowledge Forum (KF), an online collaborative knowledge building platform (Scardamalia & Bereiter, 2006). Knowledge building practices in both classrooms unfolded based on student-generated questions and ideas without pre-set procedures. Specifically, students engaged in individual and small group reading, whole class face-to-face conversations, individual and small group modeling and demonstrations, student-directed presentations, and so on. Major ideas, questions, and findings generated through various inquiry activities were contributed to KF for continual discourse. While both classes worked with an idea-centered, principle-based framework of knowledge building; students in class B (year 2) particularly engaged in reflective structuration to co-construct collective structures to frame/reframe shared objects of inquiry as the focus of their unfolding strands of knowledge building practices. The detailed processes of reflective structuration are analyzed and elaborated in Results.

Data sources and analyses

To elaborate the implementation of reflective structuration, we conducted qualitative analyses of rich classroom data, including classroom observation notes, the teacher's reflection journals, student-generated classroom artifacts, and classroom videos. To examine students' knowledge building practices in each year, we analyzed their online knowledge building discourse. First, we compared the areas (objects) of inquiry addressed in the online discourse by the two classrooms and coded students' online contributions using a five-category coding scheme created to capture productive discourse patterns (*questioning, theorizing, evidence, referring resources, and connecting and integrating*) (Zhang et al., 2011). Each note coded as "theorizing" was further rated based on a 4-point scale: *1-pre-scientific, 2-hybrid, 3-basically scientific, and 4-scientific* (Zhang et al., 2007).

Results

Reflective structuration of knowledge building practices

Qualitative analyses identified the reflective processes in classroom B related to the co-generation and adaption of epistemic structures. These include: (a) co-formulating collective wonderings (e.g. how does the brain work) based on individual interests and questions; (b) deep search, framing, and collective mapping of interrelated areas of inquiry as the shared focus of the community; and (c) individual and small-group reflection on specialized inquiry aided by the collective map of inquiry objects. The teacher engaged in ongoing noticing and envisioning of idea progress related to the inquiry areas in her reflective journals to co-engage with her students in the unfolding inquiry. Specifically, the inquiry began with ten out-door games, which triggered students' initial questions about human body. Emergent groups formed after the kids categorized individual questions. As the inquiry went deeper, students began to move on to new areas. After two months of inquiry, students reflected on his/her previous inquiry, current work, and future research. Five new areas proposed by them were furthered discussed and rephrased in a whole class discussion. As new questions and areas were proposed, the community decided to reflect on the areas of inquiry. Students started with a review of individual inquiry trajectory and connections among the specific issues of inquiry. Based on this reflection, the whole class worked together to identify new areas of inquiry based on interconnected issues. The epistemic structures thus evolved from a list of collective wondering areas to a collective map of connected areas/objects. With the support of this collective map, student continued inquiry in more specialized areas.

The impacts of reflective structuration on online knowledge building discourse

Each epistemic area of inquiry emerged from reflective interactions became a shared focus of inquiry in the classroom and online. In class A, students and the teacher co-identified five areas of inquiry as a list of overarching goals. In class B, students co-framed similar overarching goals in the beginning. However, through continual reflection on their ongoing research and unfolding directions, students in class B kept searching for progressive and connected directions of inquiry. Figure 1 shows the areas (objects) of inquriy identified by the two classes and the number of online notes written about each area. Class B made more systematic contributions to addressing a broader set of human body topics.

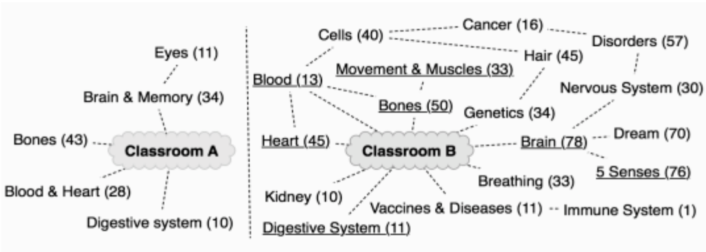

Figure 1. Areas of inquiry and the number of online contributions in each area in class A (left) and B (right).

Quantitative analysis of the KF notes shows that students in class B wrote more notes than those in class A on average (24 notes per students for class A and 36 for class B). We further coded the KF notes based on patterns of discourse contributions, focusing on the contributions that addressed a common set of five inquiry areas shared between the two classes. As Figure 2 shows, compared with class A, class B made more purposeful contributions involving asking questions, developing theories/explanations to answer their questions, integrating different ideas.

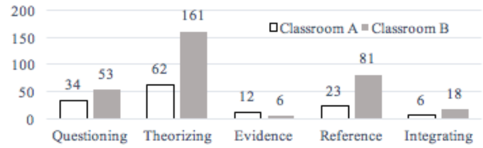

Figure 2. Contributions to shared objects of inquiry from class A and B.

The understandings related to each area of inquiry were further coded based on scientific sophistication to examine the extent to which students' explanations align with a scientific framework of human body systems. Through sustained and purposeful knowledge building work supported by collective structures, students in class B (M=3.41, SD=0.17) were able to develop a higher level of scientific sophistication of ideas in shared areas of inquiry than class A (M=2.70; SD=0.37); t (8)=3.91, p=0.01.

Discussion

This design-based study investigated reflective structuration as a way to sustain knowledge building practices in Grade 5 science classrooms. First, we documented the implementation of reflective structuration in class B. The collective inquiry areas emerged and evolved through several reflective cycles: formulating an initial list of five big "juicy" questions based on diverse individual interests and questions, expanding the list to a network of inquiry areas to include new epistemic objects (e.g. *dreams, nervous system, cancers,* and *cells*) emerged from student ongoing discourse and continual searching for interconnected areas of inquiry. The collective areas of inquiry were co-constructed and continually adapted by the community through metacognitive conversations in reflection of members' diverse input and progress. These collective goals were represented and highlighted using classroom artifacts (e.g. collective question list, and a collective map of all objects of inquiry) to guide student's attention and participation. Second, the analyses of online discourse of the two classes illustrated the impacts of reflective structuration on students' sustained and productive engagement in knowledge building. Both classrooms used the initial wondering list to organize their continual discourse online. Through continual reflection on undergoing inquiry and emergent deeper questions, students in class B kept searching for progressive and interrelated issues of inquiry to adapt existing framing of shared focus, leading to more productive and sustianed knowledge building discourse and more sophisticated scientific ideas online.

The adaptive structuration perspective provides a framework to understand and support sustained knowledge practices driven by distributed student interactions without extensive pre-scripting. Leveraging their knowledge building actions and discourse to advance collective knowledge, members in a community co-construct adaptive collective structures, which help frame what they do as a whole community and further inform individual participation and reflection. Further advancements of collaborative learning environments need to provide opportunities and supports for students to co-construct/reconstruct structures of knowledge practices and make the structures visible to students. We recently designed a timeline-based structuration tool: Idea Thread Mapper (ITM) (Zhang et al., 2015) to support student co-construction of collective structures as they engage in ongoing knowledge building discourse. Deeper understandings of how students co-construct and use collective structures to support knowledge building will shed light on the pathways towards transforming educational practices.

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Integrating Eye-Tracking Activities Into a Learning Environment to Promote Collaborative Meta-Semiotic Reflection and Discourse

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Abstract: At the beginning of a one week science summer camp designed to promote student visual, scientific and data literacy, participants were recorded viewing infographics by an eye tracking-machine. Data were shared with participants the following day as fodder for discussion about data literacy, visual representations, and information processing. The eye-tracking activities helped make visible and public students' private visual strategies. Utilizing these data and other multi-modal representations students participated in a collaborative, metacognitive, reflective process regarding their own visual strategies, the mental processes of others, and comparisons within. This activity was one of an ensemble of technological activities and artifacts that afforded students a way to collaboratively engage with otherwise private, and often tacit thoughts. Results of this work in progress suggest that this sort of computer-supported intervention could be used productively to enhance student multi-semiotic discourse and collaborative reflective inquiry.

Introduction and major issues addressed

While there has been a growing interest in utilizing eye-tracking technology for educational research, much of this inquiry considers students subjects of research rather than active participants in learning environments. In a literature survey of 81 recent education research studies utilizing eye tracking technology, Lai et al (2013) found that overwhelmingly this work focused on attention, perception, or language while only 10 such studies considered learning strategies and instructional design. We have been exploring the promise of eye-tracking technology to be integrated in the design of computer-based learning environments, supporting collaborative and reflective meta-cognitive work and student centered discussion regarding multi-modal representational strategies, data literacy, and scientific communication (Kirsch, 2005). In this paper, we focus on how an eye tracking computer intervention can be integrated into the reflective and discursive activity structures of a learning environment. The specific intervention reported on here consisted of youth summer camp participants doing a laboratory supported study on the first day of camp, then collaboratively reflecting on otherwise private aspects of their visual processing and interpretation. The student generated meaning making that happened through a multi-semiotic, collaborative discussion of this activity served as a starting point for a series of activities and instruction leading up to students researching, designing, and publishing their own science news infographics.

We are concerned with how the use of technology and various representational modalities, eye tracking or otherwise, can bolster student self-reflection, discourse, and learning. Using a situated and distributed approach to cognition, we identify instances where metacognitive reflection occurs in the public sphere through discursive practice (Kirsh, 2005). In this work in progress, we aim to identify how a varied sociotechnical ensemble of discourse and action with technology (Hall, 2011) affords for productive collaborative, multi-representational engagement with otherwise private and tacit processes and thoughts.

Background and theoretical approach

We aim to expand the use of eye tracking technology in educational research beyond making claims about perception, cognition, or attention and more towards how such technology may be used to support collaborative learning activity within designed learning environments. Our small sample size (two interventions, nine students each) and methods do not allow us to make claims about intra-mental processes. Rather, our focus is the collaborative *inter*-mental meaning making processes that occurs when peer groups engage in multi-semiotic reflective discourse.

The InfoX camp and eye-tracking intervention are part of our broader study [STEM Literacy through Infographics] that considers how to best design learning environments to prepare students for STEM (science, technology, engineering, and mathematics) literacy in an era where *'text'* captures many communicative practices above and beyond the written word. Following Halsanova *et al* (2005) we are interested in how multi-modal forms of information presentation attentive to spatial continuity and dual scripting may render complex conceptual scientific content accessible to broad and diverse audiences across boundaries of language community or prior training. Beyond an explicit focus on learning environment design, we see cognition as situated and distributed, extending "beyond the skin" and utilizing social and material resources (Kirsh 2005; Pea, 1993; Schoenfeld, 1987). We see mediating artifacts as means to publically create and access knowledge. We consider that metacognition is not only a private phenomenon, but rather is frequently mediated through public interaction. Technology and media advances in the last twenty years allow, and in fact challenge us to expand the idea of meta-pragmatics and think deeply about multi-semiotic levels of communication that harness multiple forms of communicative tools towards information literacy (Silverstein, 1993; Stein, 2008). Building on Palincsar & Brown's (1987) notion of reciprocal teaching, we seek to design learning environments with cognitive tools for meta-cognitive awareness of visual perception and interpretation. We proceed in the spirit of Vygotsky's (1978) 'general genetic law', facilitating learners to first participate in the social exchange of cultural tools and ideas on the *inter*-mental plane (public) and later take up these ideas on the individual or *intra*-mental plane (Polman, 2004). Our hope is that technologically supported, multi-semiotic artifacts may help make visible private *intra*-mental processes, make these private processes public, and then encourage dialogic meta-cognitive reflection that has lasting *inter* and *intra*-mental consequence. In this sense our theoretical focus is on the design of learning environments that utilize technologically supported artifacts to scaffold activities drawing on student experience and collaborative reflection to build knowledge from experience.

Research context

The eye tracking intervention and reflective debrief were developed as part of a week-long science summer camp, Infographic Expression (or InfoX) designed to engage middle and high school students in a meaningful process of researching a topic of scientific relevance, analyzing related quantitative data, and designing and publishing a science news infographic of their own. We worked with staff from our institution's Cognitive Development Lab to design an activity that exposed students to computer supported data collection, helped them gain deeper insight into how they process visual representations, and produced a series of artifacts and data to serve reflection and discussion. Infographics were selected and modified to include various representational forms (e.g., text, maps, images, charts, etc.) and content into four specific pre-defined areas of interest (AOI) throughout an infographic. Each infographic had a variety of representational forms, redundancy in where and how information was presented, and a variety of complexity concerning specific information. The eye tracking software captured millisecond-level records of saccadic movement, time spent in each AOI, and overall gaze pattern. The nine participants were divided into three groups of three; each group with a unique set of infographics. Students viewed three infographics with different instructions for each trial. In trial 1 students were asked to offer written responses to specific questions that could be answered by looking at the infographic. Trial 2 allowed students thirty seconds to study a new infographic and remember what they deemed most important and striking. The third trial was like the first (specific questions asked) though all three groups saw the same infographic. After each question, the real time gaze tracing was played back for students. Upon completion of the three tasks, students were escorted to a second room to complete a question worksheet and offer immediate reflections. The following day, each student group reviewed the data collected by the eye tracker and together discussed the experience with the entire class. They discussed their prior beliefs about their visual strategies, reactions to the data collected on their gaze, and the trends, patterns, and differences revealed by comparing the results of their peers. In this sense, students' own innate private processes were made visible to them and also made public to the rest of classroom.

Methods

We conducted a qualitative case study with a particular focus on the artifacts and data collected in the 2016 cycle of InfoX. During the camp itself, members of our research team rotated roles as facilitators, participants, and data collectors. A video camera and audio device recorded the entire summer camp to capture instruction, student work time, class discussions, and peer-to-peer interaction. Other data collected and analyzed include student pre-intervention worksheets, worksheets filled out during the intervention, the eye tracking data itself, student drafts of infographic, group work documents, exit interviews, and running observational notes. The InfoX team debriefed daily and later discussed key findings, trends, and other observations with the larger research group of our ongoing study. For the scope of this short paper, we focus our attention on Group 2; William, age 14 and in the first year of secondary school, Vera, age 15 and in the second year of secondary school, and Abby, age 15 homeschooled.

Findings

On day two of the camp, student groups had an opportunity to review and explain the infographics they saw to the other groups in the class. While explaining their initial reactions, where they believed they looked, and strategies for finding specific information during the question prompted infographic trial, the members of Group 2 each explained that they looked at different parts of the infographic and justified their response. Vera believed she focused mainly on bar charts and text. William indicated that he focused elsewhere, "but mainly that's because I am naturally drawn to maps, cuz I am actually really good at [that]. " Abby explained "I think I spent a lot on [AOI] 1 and 3… Not exactly sure why, I say I like colors, but then I would have gone to 1 and 4. " The instructors then presented the actual quantified data (by way of bar charts) showing exactly how many milliseconds blinded participants spent in each AOI answering the questions; the students did not know which set of charts corresponded to whom. They speculated about which 'subject' of the study they were, based on the recollection they had just offered. William rightly guessed which data was his, stating, "Well I know who I am. It's simple… Well I mean it's kinda important to note that both [participant ID] 1608 and 1602 the numbers were ultimately the same. 1605 had like, spent a crazy amount of time on AOI 2. Just wanted to point that out." Though William rightly claimed that he was subject 1605, this evidence was contrary to his earlier claims, revealing that that he *did not* primarily look at the map representation, but instead focused on a technical doughnut chart.

Group 2 then explained to their peers what the content and their responses were to the second infographic trial with no specific questions. Vera, Abby, and William explained in what order and where they believed they focused their attention in thirty seconds of viewing this infographic, referring back to their perceived habits or visual preferences. Instructors then showed the thirty second real time gaze track of one of the subjects, noting during the video that the data presented did not line up to the students' earlier claims. William quickly responded, "Well whoever did this one honestly has a hard time digesting a lot of information," and Abby claimed "I don't think it was me cuz I definitely looked at the pictures." Though Vera did not have a strong reaction, she did not argue that this might have been her info, as in fact it was. Groups A and B similarly shared out. In all three groups students recognized that their particular visual strategies varied from their peers, even when looking at the same infographic. Some students accurately identified what 'subject' they were based on the charts showing time spent in particular AOIs, though other students could not, and in some cases actually challenged that the computer did not accurately capture where their eyes 'really went'.

Lastly the class collectively reflected on and discussed their intuitions about their own ways of seeing, patterns about their visual processes revealed by the eye tracker, variations regarding visual literacy, considerations of different forms of data representation, and overall feedback for the design of the activity and what makes a 'good' infographic.

Through the course of the one-week InfoX program we observed that students gained an increased and changing awareness of their own visual processing and interpretation strategies. At the start of the week, students articulated their pre-existing expectations about how they believed they viewed complex visual information, noting that that this was not something they regularly thought about. The eye tracking activity and subsequent group reflection revealed where students actually did look in three trials. For some, these data supported their pre-existing ideas. For others, these data challenged student expectations and self-images. As the students designed their own infographics, they regularly mentioned 'AOI's' and referred back to gaze pattern and representational forms that had grabbed their own or others' attention. These conversations influenced their draft versions and final products. Regarding the eye tracking intervention and creation of her infographic Vera reflected, "It was interesting. The results weren't exactly what I expected. " Rather than assuming all people would view the infographic the same way, she said she created her infographic "how I would like to see it and also how people might want to see it." Vera's claims suggest that the eye tracking intervention served to prompt students' collaborative meta-cognitive reflection, perhaps revealing surprising insight. Further, the exercise and debrief appears to have influenced how students might focus in on the data rich components of visualization. Lastly, this activity informed students own communicative practice as they designed an infographic drawing on the principles observed in the activity.

Significance and implications of this work

The technology and multi-semiotic representational tools used in this program were intended to give students some exposure to an experience where they were both the 'subjects' of the study and also the researchers, interpreters and meaning makers. These interventions show promise at bolstering students' capacity to reflect on and discuss mental processes that were otherwise private and tacit. Once students gained an awareness of their own and also peer visual processed, InfoX instructors sequenced further activities to build upon this knowledge.

The InfoX program provided an opportunity to consider how technologically mediated lessons and activities can be utilized as early interventions to make students' visual processing visible to themselves and their peers. This work in progress illuminates how the processes of visualizing complex data, publically making sense of these data, and dialogically moving between the *inter* and *intra*-mental plane may empower students to draw from their own and their peers' prior and emergent knowledge to interpret and design infographics. This can inform the design of computer-supported collaborative learning environments that increase students' epistemic agency and ownership.

Future studies and learning environment design work might expand upon this line of inquiry in several directions. We will continue to explore how learning environments can be designed to expose otherwise private mental processes as a means towards guided, collaborative multi-semiotic discourse to drive understanding of STEM content. In these student-centered environments knowledge is built by the students, using technologically mediated semiotic 'texts,' and the instructors work mostly as collaborators or coaches. Further, we hope to bolster students' ability to communicate complex ideas with broad audiences. We support continued veins of research that consider how technologically informed learning environments might be developed to prioritize data accessibility, make mental processes visible, and bolsters students' ability to collaboratively engage in meta-cognitive work utilizing multiple representational forms.

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Children's Participation in Rulemaking to Mitigate Process Problems in CSCL

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Abstract: In CSCL studies, children have been largely excluded from decision-making processes around orchestration by being required to follow predetermined scripts for collaboration. However, opportunities to acknowledge issues surrounding the process of collaboration (i.e., shared resources) and resolve related problems are important for the development of higher-order collective cognitive processes. Thus, considering cognitive apprenticeship, this case study illustrates a session at an afterschool club where children worked on collaborative design projects with Minecraft and were empowered to participate in decision-making processes surrounding classroom rules and orchestration of activities.

Keywords: Socio-metacognition, agency, cognitive apprenticeship, sharing, Minecraft, CSCL

Introduction

Many CSCL settings favor the creation of predetermined rules that minimize conflict and reduce the necessity for students to solve social problems such as those surrounding shared resources (e.g., Schwarz, de Groot, Mavrikis, & Dragon, 2015). However, learners in these predetermined settings lose opportunity to understand non-task related, social problems arising from collaboration processes and practice important decision-making processes. For example, learners need to understand that sharing resources is an integral process for achieving common goals because physical and/or virtual resources in CSCL are often shared among individuals. Based upon the perspective that participation itself is a learning process (Lave & Wenger, 1991), we argue that children need to be active participants in the resolution of issues that emerge during collaboration in order to learn about and practice evaluation and regulation of collective processes. To support children's participation in such issues, it is important to make collaborative aims and underlying thinking processes explicit, model behaviors, articulate thinking, and coach children as they work through similar processes (Brown, Collins, & Duguid, 1989). In this way, we can immerse children in these issues and support them as they figure out how to resolve issues related to collaboration through testing, synthesizing, evaluating, and negotiating future activity.

Towards this aim, we examined children in an afterschool club as they worked on collective design projects by using a variety of tools including Minecraft. Using computers often led to conflicts, as a limited supply caused students to fight over control of the tools. Having to share a virtual space also caused conflicts. Rather than solving the issues for them in advance, we ran a session designed to help children understand the issues related to limited resources, try out different ways to orchestrate collaboration, and create their own club rules. Then, we conducted a qualitative case study to answer the research question: *how* did children participate in the collective sense-making process surrounding shared resources during the CSCL afterschool club? The study also discuss whether taking time to focus on such process provides benefits to students.

Conceptual framework

Learners in collaborative environments need to practice how to collaborate and how to solve problems in groups (Schwarz et al., 2015), because collaboration involves higher-order forms of group cognition rather than a simple sum of individual contribution (Stahl, 2013). Thus, it is critical to support not only learners' cognitive activities about domain knowledge, but also to develop collaborative sense-making processes that surround it. Previous studies in CSCL have adopted tools and scaffolds to enhance the quality of collaboration at the level of the small group (e.g., Borge & White, 2016). However, we argue that previous studies overlooked the importance of empowering learners to adopt the role of main agents for creating rules for the community.

Process problems regarding shared resources

Learners in CSCL settings are often asked to solve domain problems that require higher-order thinking (i.e., inquiry skills, argumentation); solving the given domain problem becomes the primary goal for the group. Thus, the conflicts that emerge during collaboration (i.e., limited resources, shared environment) are regarded obstacles and are therefore mitigated in advance by teacher rule-making. However, instead of neglecting or eliminating conflicts among individuals, it is important to consider what conflicts learners may confront and what could be learned by solving problems together.

In CSCL settings, learners are usually required to collaborate with shared or constrained resources in both physical and virtual spaces. In terms of sharing physical resources (i.e., laptops), research indicates that if learners share a computer screen but have an individual mouse, which allows them to make concurrent input, a high level of collaboration can be achieved (Gómez et al., 2013). However, such predetermined rules deprive learners the opportunity to understand the problem associated with limited resources and to determine how to overcome this problem. It also may not always be feasible to provide enough technology due to limited budgets and technical issues. In terms of a virtual environment, simultaneous access the same virtual space can cause conflict. For example, in Minecraft, an online video game for building virtual artifacts, multiple users can build at the same time in one world by using different computers. Thus, conflicts might arise if they envision different creation in the same location without achieving shared understanding about the project. Given that our previous iteration indicated that children might lose their motivation in collaborative activities when adult facilitators minimized conflicts through goal-oriented reasoning (Jung, Yan, & Borge, 2016), we designed a session where facilitators would empower learners to collectively manage process problems during collaboration.

Fostering children's agency as part of the club activities

Many of the scaffolds and tools for CSCL are designed and predetermined by adults such as researchers or teachers (e.g., Borge & White, 2016), but the culture of collaboration should also include children's autonomous collective problem solving. In this regard, we follow aspects of cognitive apprenticeship models of instruction to include children as the main agents dealing with process problems and to facilitate their attempts to solve these problems during collaboration (Brown et al., 1989). Cognitive apprenticeship emphasizes authentic practices where learners are situated in their own problems and generate solutions for themselves within enculturation (Brown et al., 1989). We ran the session to bring these issues to the forefront and help children engage in thinking about the issues of sharing resources, testing different solutions, and collectively discussing related decisions for their collaborative projects. During this session, children not only made rules for sharing resources but also modeled the whole process of decision making for collaborative activities in future. We examine how the session engaged children in such process to mitigate conflicts among themselves.

Methods

Setting and participants

The research was conducted over 16 weeks during Fall 2015, in a weekly afterschool club at an elementary charter school in the Northern US. Two adult facilitators led four groups of children (16 total) between 8 and 12, who worked collaboratively on design projects (i.e., building a garden) by using diverse media (i.e., drawing, Legos, Minecraft). Six were female, ten were male, and eight were non-Caucasian. For Minecraft (Figure 1, a), as we had a limited number of laptops, each group had to share two laptops. Each laptop could access the same server on Minecraft, so children could work on a group project together from different laptops (Figure 1, b). Children also took turns to use the Teacher account (one or two children per session), which has more functions (i.e., freeze other players) but adds more responsibility to the club community.

(a) (b)

Figure 1. Example of children's design project with Minecraft (a) and the scene of the setting (b).

This study focuses on Session 6 (75 min), which was designed for children to begin using Minecraft and engage in problem solving associated with sharing resources. In this session, the facilitators not only prompted children's discussions but also modeled collective, decision-making processes. The session flow generally followed six continuous steps. Step 1: The facilitators announced that a limited number of laptops were available and presented two options for sharing a laptop. In Option 1, command keys were divided so that each person could press simultaneously, while in Option 2, one person verbally guided the other who actually pressed the keys. Step 2: Each group worked in Minecraft to build their design experimenting with the two options (20 min). Step 3: The facilitators led a whole-class discussion about the pros and cons of each option to identify its claims and trade-offs. Step 4: Children decided which option they would use by articulating their rationale. Step 5: Children continued to work on Minecraft (20 min). Step 6: The facilitators led a whole-class discussion aimed at getting children to discuss difficulties during building, including any frustrations and problems they faced. Afterward, children were prompted to think about and propose additional rules needed for building in Minecraft to address the problems they experienced. Steps 1-4 were particularly about sharing physical resources, and Steps 5-6 were about sharing a virtual space.

Data source and analysis

We conducted a case study to explore authentic situations with in-depth analysis (Creswell, 2013). The data was collected in the form of audio and video recordings (296 minutes total from four groups). We analyzed the data by (1) developing content logs (Jordan & Henderson, 1995) that included a general description of events that occurred every 2 minutes, (2) collectively reviewing the recordings and the content logs to identify episodes of children's rulemaking, transcribe, and code them, (3) conducting microanalyses to deduce patterns of children's decision-making processes about evaluation and orchestration of club rules.

Findings

Using one's own experience as a tool to articulate reasoning

During the session, children as main agents could establish their own rules for sharing physical and virtual resources, via reflecting on their experiences, sharing ideas, or building upon each other's ideas. Especially when setting a rule for sharing physical resources (laptops), we identified that children used reasoning based on their own experiences and reflections to make decisions. When children had a discussion about the pros and cons of each option for sharing one laptop between two members (Step 3), children reflected back on their own experiences from Step 2 and used it as evidence for their reasoning. For instance, the episode of Marcos and Patty from Group 1 shows an alignment throughout their experiences, discussions, and decision-making. During Step 2, Marcos voluntarily verbally guided Patty while she built artifacts in Minecraft. Marcos also drew on papers to specify plans and thoughts, unlike other children who guided only verbally. During the discussion (Step 3), Marcos used this experience as his rationale to support Option 2. He said "This [Option 2] is a sort of thing for that they can do what they want. Um, so since I like sketching (showing his drawing to others), I prepared a couple of pieces of papers for what I will [while the partner was working on Minecraft]. … And I like planning! If you don't like to build in Minecraft, you can do this [drawing]." This transcript shows that Marcos asserted the pros of Option 2 with explanation of what he and his partner did. He even showed his drawing as evidence to support his claim that Option 2 could be more beneficial especially for children who might not like to play Minecraft. Then in Step 4, Marcos and Patty chose Option 2 as the rule for their further projects. This episode shows that children were not only able to understand the pros or cons of each strategy but also to use their experience to support their arguments for choosing rules.

Presenting problems from one's experience during negotiation

The session also helped children to bring up realistic problems they experienced and then make community rules that all individuals could agree upon, particularly for sharing a virtual space. Since children used a common server in Minecraft, many of them experienced conflicts due to territory invasion. During the second whole-class discussion (Step 6), children voluntarily brought up problems and frustrations related to the issues of territory. Harry (Group 1) mentioned that somebody placed water in his group's space; Bruce (Group 3) complained that somebody broke down his group's artifacts; Eric and Aaron (Group 2) stated that Group 3 built on their territory. Then, facilitators reminded them that they had to share a common server in Minecraft and asked what rules they wanted to establish to ensure that all students could feel safe to explore while being considerate of other's creations. The facilitators invited children to share ideas and establish rules collectively.

14 Iman: First, no building in others' territory unless they ask help to build something.

15 Facilitator2: What should we do then if somebody doesn't follow that rule?

16 Marcos: Um, ask a teacher [student who uses Teacher account] to freeze them!

17 Patty: [Responsible for Teacher account this session] No, I don't want to do that.

18 (Some arguments going on)

19 Iman: Each day we should have a chart, and then if you build on other's territory

20 and check mark. Once you get down to zero check mark, you get frozen for
21 five minutes.
22 Facilitator2: That's a lot of check marks. …
23 Karen: We should get two! To get two chances!
24 Patty: How about one. …

Based on the rule that Iman suggested (line 14), the facilitator prompted children to create more specific rules (line 15). Then, other children shared their ideas, agreements or disagreements (line 16-24). One suggestion was for the child taking on the responsibility of 'teacher' to freeze a player (line 16). However, the 'teacher' for that session stated that she would not feel comfortable freezing someone (line 17). Finally, children came to a consensus for a rule that 'if a person built in other's territory, he/she can be given one chance to adjust their behavior, otherwise he/she will be frozen in Minecraft for five minutes.' Throughout this process, children acted as the main agents to set their own rules and reconcile solutions via multiple attempts to make agreements. This episode shows that children pursued their autonomy by creating rules that they could manage by themselves.

Implications

Our results indicate that young learners can successfully take the role of main agents to understand process problems they confront, test different strategies, reason about experiences and needed rules, and establish their own rules about shared resources for better collaborative environments. During the session, children reflected upon their own experiences and practiced reasoning for choosing/making rules. This process can be seen as the enhancement of socio-metacognition, which is important for high-quality collaboration and socially shared regulation (Bore & White, 2016; Järvelä et al., 2015). This study also explores the possibility of applying cognitive apprenticeship models not only to cognitive development of domain knowledge and practice, but also to solving socio-emotional problems. However, we also recognized that not all children participated equally in the rulemaking process, as some of them were not engaged as active agents during the session. Our next study may focus on how to include all the children in process-related problem solving activities.

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Anchor Code: Modularity as Evidence for Conceptual Learning and Computational Practices of Students Using a Code-First Environment

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Abstract: In response to increasing calls to include computational thinking (CT) in K-12 education, some researchers have argued for integrating science learning and CT. In that vein, this paper investigates conceptual learning and computational practices through the use of a code-first modeling environment called Frog Pond in a middle school classroom. The environment was designed to enable learners to explore models of evolutionary shifts through domain-specific agent-based visual programming. It was implemented as a curricular unit in seventh grade science class. We analyzed video and log data of two contrasting student pairs. This paper presents one of our findings: Development of modular core functional code-units or what we call *anchor code*. Anchor code is a body of code that creates a stable base from which further explorations take place. We argue that anchor code is evidence for conceptual learning and computational practices.

Introduction and theoretical background

There are increasing calls to integrate computational thinking (CT) into K-12 education (e.g., diSessa, 2000; Weintrop et al., 2016; Wilensky et al., 2014; Wing, 2006). One thrust of this work has been to bring computational tools directly into science classrooms to help learners engage in authentic scientific practices and grapple with difficult concepts (e.g., Papert, 1980; Sengupta et al., 2013; Weintrop et al., 2016). Computation can help enrich science education by bringing tools, practices, and methods that more authentically align with modern science fields. On the other hand, the study of science can provide a context in which computational thinking is powerful.

This paper investigates student learning of conceptual ideas and computational practices around a "code first" (Horn et al., 2014) programming toolkit for adaptation in a middle school biology classroom. Using Camtasia video and computer log data from pairs co-constructing code, we investigate learning about evolutionary change and computational practices. To characterize CT practices, we draw on a taxonomy consisting of computational thinking practices specifically relevant to science and math education developed by Northwestern's CT-STEM project (Weintrop et al., 2016). The scientific phenomenon we focus on is adaptation. An extensive body of work has shown that programming and computational models can help learners grapple with difficult concepts like natural selection and genetic drift (e.g., Centola, Wilensky, & McKenzie, 2000; Horn et al., 2014; Wagh, 2016; Wagh & Wilensky, 2013). Much of this work has used agent-based models (ABMs). Research has shown that programming agent-based models using graphical, domain-specific primitives (i.e. coding blocks) can help learners develop mechanistic understandings of evolutionary change (Wagh, 2016). This type of understanding is important for learners to move from thinking about evolution as a deterministic, directed process to thinking about it as a decentralized process that emerges from a multitude of events involving interactions between individual organisms.

Frog Pond: An example of a code-first environment

We designed a computer-based learning environment called *Frog Pond* to be used in conjunction with middle school science curriculum on evolution. Frog Pond is an example of a *code-first modeling environment* (Horn et al., 2014). A code-first modeling environment is one in which the primary mode of interaction is through code, it is extremely easy for a learner to create a program within a few minutes or even seconds of using the environment, and diverse outcomes can be observed from a small set of rules. Frog Pond is an agent-based code-first environment that uses a blocks-based interface. It was created using a blocks-based programming environment called NetTango (Horn & Wilensky, 2011) that provides an alternate blocks-based interface to NetLogo (Wilensky, 1999).

In the Frog Pond environment, learners program instructions for a group of frogs in an ecosystem using domain-specific, blocks-based primitives (See Figure 1). There are eight behavioral blocks ("hop", "chirp", "left", "right", "spin", "hunt", "hatch" and "die"), two logic blocks ("if" and "if- else"), and a probability block ("chance"). Students can drag and drop these blocks to construct a program. On running the program, each frog repeatedly enacts the encoded instructions to interact with other frogs and a simulated environment that includes lily pads and flies. Within this environment, variations in frog size have multiple tradeoffs. More information about Frog Pond is available here: http://tidal.northwestern.edu/nettango/. The simulation can result in changes in the frog population: 1) growing bigger or smaller (directional pressure), 2) staying around the same size (stabilizing pressure), or 3) separating into two distinct sub-populations, consisting of larger and smaller individuals (disruptive pressure).

Figure 1. A student-generated program.

Frog Pond: The curricular unit

Students took part in a curricular unit driven by an overarching question: Why are there so many different kinds of living things on earth? To answer this question, we asked students to consider real-life examples of adaptation and to explore mechanisms of adaptation by programming virtual frogs in our simulated ecosystem, *Frog Pond*. Students engaged with five increasingly sophisticated challenges through the unit. Each challenge was designed to foreground concepts related to population dynamics and selection pressures. For example, in Challenge 2, students were asked to create a stable population consisting almost entirely of little frogs. The goal of this challenge was to experiment with directional selection pressure—one that drives organisms' traits in one direction over successive generations.

Research question

As they progressed through the curriculum, what forms of learning about evolutionary change and computational practices were visible in the student pairs' programming approach and discourse around code?

Methods

Data collection

We implemented the Frog Pond curriculum at a middle school in an ethnically diverse suburb of a large midwestern city. Nearly 130 students from six seventh-grade science classes participated in the unit over a period of 8 classes. About 100 students consented to participate in the study. The science teacher who usually taught these classes led the activities. Students worked in pairs throughout the unit. Camtasia screen capture recordings were collected from these focal students to capture their on-screen work and conversations. We also video recorded whole class interactions with two stationary video cameras.

Analysis

Video analysis of student pairs

We selected videos from an early and advanced challenge from two focal pairs as contrasting cases for analysis. Pair 1 had succeeded in both challenges while Pair 2 did not succeed in either. This contrast allowed us to compare learning interactions that resulted in different levels of success. We identified segments in which students made *code changes* (added or removed a block) or *code parameter changes* (changed parameter values of a block (e.g., chance %)). We then identified discourse segments before and after each change. These segments provided clues about students' rationale for modifying code or about what students observed when they ran the simulation, and how they accounted for it. These episodes were analyzed to examine themes related to conceptual ideas about evolutionary change, and computational practices from the NU CT-STEM framework.

Computer log analysis of student pairs

Each time a student clicked the Play button, a log entry was generated, recording what blocks were used with what parameters. Across the 5 days of deployment, 12,484 entries of runs were generated. We focused on the analysis of 2585 lines generated by focal students for triangulation. We focused on extracting two key features: Code blocks used in each run, and changes in parameters and blocks used in each run. Below is an example of a log entry: entry:`hop(1);left(60);hunt(10s);chance(40%);if(full?);hatch(no-variation);end;end;` (1)

This log entry shows a program composed of 6 blocks with 2 nesting blocks ("if" and "hatch"). Given this information about student programs, we could obtain differences in programs used in sequential runs. We chose to use Levenshtein Distance (LD) to measure this. LD is the minimum number of changes that are needed to make alphabets string identical to the next. We wrote a Python script to convert the original log to a string to obtain meaningful LD between runs.

Findings

Anchor code: Modularity as evidence of conceptual learning and CT practices

Our analysis of learners' code changes in an early and advanced challenge led to the development of a construct that we call *anchor code*. Anchor code refers to a body of code that creates a stable base from which further explorations take place. There were differences in the expression and grain size of anchor code in the two pairs as well as in their quality in stabilizing the system.

For Pair 1, anchor code was located in a set of code blocks that would make the population stable. For instance, when they began Challenge 5, Cory said: "How do we do what we did the one time, the one that was really stable?" They proceeded to construct a set of code that was nearly identical to what they had constructed as part of Challenge 2. Using this code, they attained a stable population that fluctuated around a steady carrying capacity. They then proceeded to make minor modifications to this code in order to meet features of this new challenge. In contrast, for Pair 2, anchor code was of a lower level of modularity and was less stable. Though this pair made several code changes in early and advanced challenges, they came to consistently rely on specific chunks of code to produce specific outcomes. Anchor code was seen in specific strategies using smaller chunks of code to produce specific effects in the model. For instance, Pair 2 did not succeed in stabilizing the population, though they avidly avoided a population explosion and extinction. This suggested that they recognized the importance of maintaining stability in the population, though they did not succeed in doing so through the code alone. Pair 2 used `chance % [die]` and repeatedly modified the `chance%` parameter to maintain stability.

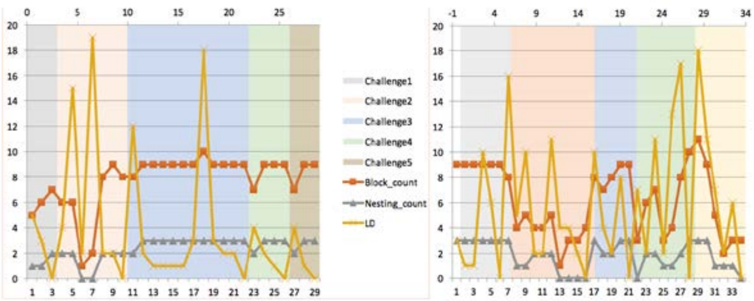

Figure 2. Pair 1's programming to the left, and Pair 2's to the right.

We found evidence for anchor code in the log data. Pair 1's progress in programing (Figure 2, left) showed increasing stability. In early challenges, the pair made radical changes to their code as shown in the high LD peaks. From Challenge 3, they entered a more stable stage of coding. They made one large change and then mainly small continuous tweaks to the code, as shown in the valleys after occasional high peaks. In contrast, Pair 2's programing progress (Figure 2, right) did not have a clear pattern. In Challenge 1, they used almost all of the available blocks. From the second half of Challenge 2, these measures changed without a clear trend.

We see anchor code as evidence of conceptual learning and computational practices. It is conceptual because students' ways of using the anchor code indicated that they had parsed down the challenges into different sub-problems. For instance, pair 1's work indicated that they broke down the challenge into a population stability problem (population dynamics), and a shifting distributions problem (adaptation). Computationally, anchor code aligns with computational problem solving practices related to developing modular computational solutions.

Discussion

Our goal was to explicate forms of conceptual learning and computational practices in Frog Pond, a code-first modeling environment. This paper presents one of our findings related to the development of *anchor code.* We argued that anchor code is evidence of conceptual learning and enactment of computational practices. Conceptually, the emergence of, and student discourse around this stable base of code suggested understandings related to mechanisms underlying maintaining stability in a population, and selection pressures leading to shifts in a population distribution. Though the grain size of their strategies was different, both pairs developed ways of dealing with these two problems in the model. Computationally, anchor code reflects the development of modularity, an important computational practice. This finding has implications for the design of programming environments as well as the design of activities for programming in science classrooms. In future work, we plan to extend these analyses to other student pairs and across challenges to investigate more nuanced shifts in learning of conceptual ideas and computational practices.

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How Did a Grade 5 Science Community Co-Construct Collective Structures of Inquiry?

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Abstract: This study investigates how a Grade 5 science community co-constructed collective structures of inquiry in the form of "research cycles" to support sustained inquiry in a whole school year. Qualitative analysis of field notes, classroom videos, and student notebooks documented the evolution of research cycles. Analysis of student interviews showed how this structure was used and adapted by individual student to position and monitor knowledge progress and plan for further inquiry. Content analyses of student online discourse in Knowledge Forum indicated that students made more purposeful contributions aligning with the research cycle after formation.

Introduction

Over the past two decades, learning scientists have made major advances to explore how authentic inquiry and knowledge-building processes may be enabled among students to achieve deep and productive outcomes. Extensive studies have examined the social and cognitive processes of inquiry-based learning and knowledge building as well as teacher and technological scaffolding to support these processes (Bell et al., 2010; Hmelo-Silver, Duncan, & Chinn, 2007; Reiser, 2004; White & Frederiksen, 1998). Despite the conceptual insights developed, we, as a field, still face the challenge of how to bring sustained inquiry into classrooms to transform educational practices. To address this challenge, researchers argued for the need of a social practice perspective to support this line of work (Hakkarainen, 2009; Stahl & Hesse, 2009), which will address idea-centered knowledge building processes in conjunction with the cultivation of social practices that guide, channel, and sustain the participants' personal and collaborative efforts in creative ways. Current classroom practices to carry out inquiry-based learning tend to enact inquiry as a set of procedures to address pre-defined tasks and challenges. This routine-based notion of practices tends to underestimate the role of participants' agency and future-oriented imagination that drive dynamic changes of social practices. In real-world knowledge-building practices, participants continually build on and advance the knowledge assets of their community by generating and identifying promising ideas and improving the them through sustained inquiry and discourse; by formulating deeper problems as solutions are developed; and by assuming leadership and responsibility at the highest levels instead of relying on the leader to tell them what to do (Amar, 2002; Dunbar, 1997; Sawyer, 2007). They do not simply enact repeated procedures but also continually create and adapt their social practices as their knowledge is advanced (Knorr Cetina, 2001, Zhang et al., 2009).

This research explores a dynamic approach to inquiry-based knowledge practices drawing upon the Knowledge Building pedagogy (Scardamalia & Bereiter, 2006), a renowned inquiry-based program to cultivate authentic knowledge-creating practices. Different from many other inquiry-based learning programs in which students are required to work on predefined tasks/topics using step-by-step procedures and scripts, Knowledge Building adopts an idea-centered and principle-based approach to classroom design. Students and their teachers co-construct and reconstruct the flow of inquiry as their work proceeds guided by a set of knowledge building principles (Scardamalia, 2002; Zhang et al., 2011). A challenge arises pertaining to how the idea-centered, open-ended actions/interactions are translated into coherent and supportive classroom practices without extensive teacher pre-scripting. In light of social practice theories that highlight the interplay between human agency and social structures in sustained production and transformation of social practices (Giddens, 1984; Knorr Cetina, 2001; Sewell, 1992), our empirical analysis of how productive knowledge building communities identified an important socio-epistemic mechanism enabling sustained practices of knowledge building: reflective structuration by which students co-construct, adapt, and use collective structures to guide their collaborative work with ideas (Zhang, 2012). The collective structures serve as shared frames signifying structural properties of inquiry, including the epistemic objects/issues to be investigated as the focus of unfolding strands of practices (epistemic structure) (Knorr Cetina, 2001), productive ways to conduct research (pragmatic structure), and who should work whom in what roles (participatory structure) (Zhang, 2012). Students use such co-constructed structures to monitor and regulate their joint inquiry and position their roles and contributions. The purpose of this study is to investigate how a Grade 5 science community co-constructed the collective structures of inquiry in the form of "research cycles" to support an emergent trajectory of inquiry in a year-long initiative.

Method

Classroom contexts

The study was conducted in a Grade 5 classroom with 19 students (10-11 years old) from upstate New York in 2014-2015. The students investigated human body systems with Knowledge Forum (Scardamalia & Bereiter, 2006). Knowledge building practices in the classroom integrated individual and small group reading, whole class face-to-face conversations, individual and small group modeling and demonstrations, and student-directed presentations. Major questions and findings generated through these activities were contributed to KF for continual discourse.

Data sources and analyses

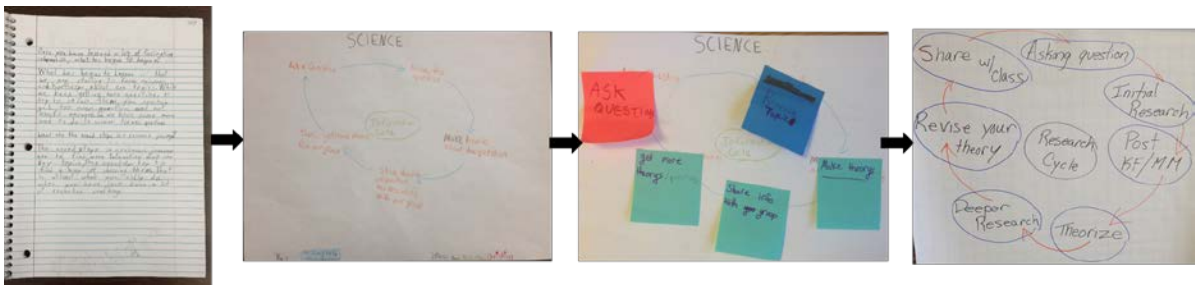
To understand the evolution of the "research cycles", we conducted qualitative analysis with rich classroom data. Reviewing field notes which recorded classroom activities in the whole year yielded the discovery of key events to zoom into. Classroom videos capturing these moments were transcribed and analyzed using a narrative approach to video analysis (Derry et al., 2010). Meanwhile, pictures of students' notebooks and classroom artifacts provided additional information about the processes involved in the process. In order to understand how students used the pragmatic structure after formation, we interviewed the students who agreed to share their comments. The interviews were transcribed, analyzed with open coding (Charmaz, 2006) and interpreted using a descriptive method.

To examine relationships between the actions in the research cycles and students' contributions to the collective discourse, we coded students' online discourse in terms of their contribution types (Zhang et al., 2011). In line with the essential actions on the inquiry cycles, the level 1 categories include *questioning, theorizing and explaining, collective evidence and referencing sources* as different ways of doing research, and *connecting/integrating* as an outcome of knowledge sharing. Under the level 1 categories, a set of codes capture more specific productive discourse patterns: *factual question* vs. *explanatory question; idea initiating wonderment* vs. *idea deepening question; intuitive explanation, alternative explanation vs. refined explanation, and evidence.*

Findings

Evolution of the research cycles over the whole school year

Analysis of field notes, classroom videos, pictures of students' notebooks, and artifacts created by students revealed the following main phases involved in the evolution of the research cycles (see Figure 1):



(a) (b) (c) (d)

Figure 1. Evolution of Research Cycles.

Phase 1- Reflection on individual journey of inquiry: In early November, when the teacher noticed students actively commented and built upon each other's ideas, he brought up the concept of research journey. With two questions provided by the teacher, each student reflected reflect on their own learning journey, in terms of where they were now and where to go next. Each student reflected on their previous inquiry and wrote down the answers in their notebooks (see Fig. 1a). Students first shared and discussed their answers in small groups. Later the teacher they organized a whole class discussion to share the reflection.

Phase 2- Co-generation and improvement of small group research cycles: Students worked in small groups and generated group-based research cycles according to their individual reflection on research journey and experience in collaborative inquiry. Most of the research cycles generated by small groups included some similar components (see Fig. 1b). Each small group used their own model to reflect on their knowledge building work and decided what they needed to do for deeper inquiry. After gaining deeper experiences with the inquiry process in small groups, the five small groups revisited and updated their research cycles in mid-December, mostly to refine the sequences of the components and rephrase the components (see Fig. 1c).

Phase 3- Synthesis of small group research cycles into the collective research cycle: In the January of 2015, the teacher encouraged students to reflect on their previous research and develop a collective model of research that everyone can use to guide new research in the Spring. Students first identified the first three components: asking a question, initial research, and sharing online or in whole class meetings. After that they proposed and included four more components: theorize, research deeper, revise theories, and share within the class (then start over), leading to the finalized collective research cycle, which was hung on the wall for students to refer to (See Fig. 1d).

Phase 4- Adaptive use of the collective cycle by individuals and small groups: After formation, students revisit the collective structure from time to time in their subsequent inquiry. All the seven students interviewed thought the research cycle was helpful in guiding their knowledge building process. Analysis of their reflective comments on how they specifically used the research cycle yielded two categories: (a) following the cycle; and (b) adapting the cycle. A few of the students followed all the components in order when they investigated different topics. For example, some students mentioned: "*I did everything on the cycle." "All of the topics I did, I always did that order……*" Other students used the structure in a more adaptive way, like: using part of the cycle ("*I kind of using it... I did pretty much my own thing...*"); using as baseline to develop personal cycle ("*I would use the cycle to guide me...I would use just like baseline...I have my own research cycle…*); and using flexibly when needed ("*...my first question was schizo… the research cycle for me is kind of smaller. It can be larger if...*").

Knowledge building achievements in Knowledge Forum

We analyzed how students made various types of knowledge-building contributions as reflected in their online discourse before and after the emergence of the research cycles over the whole school year (see Table 1). Analysis indicated that before the discussion of the collective research cycle, the most visible online contributions were relatively broad explanatory questions about the body systems and generated intuitive explanations. After the negotiation of the research cycles that systematically highlighted a diverse range of specific knowledge building actions, students had a large number of posts raising idea-initiating questions and idea-deepening questions, elaborating ideas using referential sources of information, using evidence to support or challenge ideas, providing alternative explanations, and connecting and integrating ideas to develop coherent understandings.

Table 1: Students' knowledge building contributions in Knowledge Forum

Contribution Type		Before research cycles	After research cycles
1. Questioning	Factual question	8	8
	Explanatory question	45	18
	Idea initiating question	17	48
	Idea-deepening question	24	70
2. Theorizing/ explaining	Intuitive explanation	110	114
	Alternative explanation	13	34
	Refined explanation	31	29
3. Evidence		18	88
4. Referencing sources		24	167
5. Connecting & integrating		1	7

Discussion

This study examined how a Grade 5 knowledge building community worked together to co-generate a collective structure in the form of "research cycles "and used the structure adaptively to sustain productive knowledge building over a school year. Focusing on their initial questions and interests about human body systems, students first conducted inquiry based on their intuitive sense of the process of research as it had been loosely practiced in their prior schooling experience. As Table 1 suggests, their actions of inquiry typically involved asking broad questions about human body systems, generating intuitive explanations, and finding refined ideas using information sources. Reflecting on their initial journeys of research as individuals, small groups, and a whole community provided a dynamic social context by which the pragmatic structure of the research process emerged and was reified as formal research cycles. The emergence of the research cycles underwent several iterative cycles of reflective talks: students reflected on their journeys of research in small groups, and bootstrapping their reflective discussions, they made efforts to "peek" into the practices of scientists to adopt essential components of research. The research cycles of the small groups were shared and discussed in a whole class discussion and used by the small groups for a period of time. Based on their trial of their research cycles, students then reconvened as a whole community to generate a collective model of research cycles, as a structure-bearing artifact. The teacher hung the research cycle model on the wall to ease its use. Through the intentional and adaptive use of the research cycles as a local structure of inquiry, students conducted sophisticated knowledge building practices as a community. The profile of knowledge building contributions in the community's online discourse was diversified in reflection of important components of the research cycles.

Aligned with the findings from our other study (Tao et al., 2015), this analysis guided by the adaptive structuration perspective contributes to understanding sustained knowledge practices driven by distributed student interactions without extensive pre-scripting. Clearly, deeper research on the teacher's role in facilitating the structuration process is needed to better understand such dynamics and shed light on specific designs to implement reflective structuration in classrooms.

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Learning About Climate Change Through Cooperation

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Abstract: Students maintain a range of alternative ideas around the causes of climate change (Rye et al., 1997). To help students diversify their repertoire of ideas, we engaged students in a cooperative activity in which individual students chose to investigate one of three possible topics (meat-eating, albedo, or ozone), and then reported back to their peers. Students investigated Netlogo (Wilensky, 1999) models that included features relevant to their chosen topic. After exploring one of the computer models, students met in jigsaw groups (Aronson & Patnoe, 2011). Results on assessment items matched to each investigation show that scores improved across all topics for all students. However, students in the meat-eating investigation show more improvement for the meat-eating item, while students who investigated albedo and ozone performed equally well on all items. These findings suggest that the jigsaw activity helped all students learn about the causes of climate change from their peers.

Keywords: knowledge integration, climate change, jigsaw, computer models

The major issue

Middle school students maintain a range of alternative ideas around the causes of global climate change (Rye, Rubba, & Wiesenmayer, 1997). One of the most strongly held ideas is that ozone hole depletion and ultraviolet radiation are the primary causes for global warming. In order to help students integrate new ideas about climate change into their repertoire, we implemented student-led computer-based investigations, as well as a collaborative jigsaw activity (Aronson & Patnoe, 2011) to promote understanding of causes of global warming.

One way to help students integrate new ideas about global climate, such as the effects of greenhouse gases, is through computer models (Vitale, McBride, & Linn, 2016). Through model use, students can alter model features and observe the impact on temperature. For example, students can change the number of factories running at a time and monitor the relationship between greenhouse gases and temperature through graphs. Yet, given the complexity of the topic and the range of factors to be studied, students may lose interest or become uninvolved in the investigations. To encourage student participation and interest, we implemented a collaborative jigsaw activity. The "jigsaw method" (Aronson & Patnoe, 2011) allows for students to engage in deep exploration of model features while also supporting student involvement (Lazarowitz et al., 1994) and cooperative integration of new ideas. By allowing students to choose their own investigation and engage in discussions with their peers, students can discover the value of finding answers for themselves and working together with other students to gain new knowledge (Songer, Lee, & Kam, 2002). Yet, whether students benefit equally from listening to their peers and investigating their own topics is an open question.

In order to promote a greater number of ideas around global warming, students chose one of three model-based investigations: meat-eating, albedo (surface reflectivity), or ozone. Following students' investigations, two students representing each topic met in a small group to discuss their findings. We have two main research questions: 1) Do all students make more conceptual links across all topic areas at posttest compared to pretest? 2) Do students become "experts" in their topic areas?

Potential significance of work

The work presented here attempts to not only explore methods that successfully teach students about factors related to climate change, but it also seeks to validate a jigsaw activity as a productive way for results of computer simulations to be shared. Specifically, is personally exploring a computer model just as effective as hearing about a model from a peer? By showing gains from pre- to posttest on three assessment items that match the investigation topics, we suggest that jigsaw activities allow students to delve into topics of interest through computer model exploration, while also supporting knowledge gains in areas they did not personally explore.

Methodological approaches

We tested 273 8th grade students from the classrooms of 2 teachers at a middle school in the northwest United States. Students used the web-based inquiry science environment (WISE) unit *What Impacts Global Climate*

Change? The unit consisted of a 5-class-period lesson on climate change, with a focus on the chemical reactions that affect global temperatures. Following the main unit, students began a 2-day *challenge* unit extension during which students chose to investigate one of three topic options related to global climate change.

Independent investigation

During the challenge unit, students had the opportunity to independently investigate the relationship between climate change and one of the following topics: meat-eating, albedo, or ozone. Each student ranked the investigations by preference. The second author made great efforts to ensure that each student was able to investigate either their first or second choice while ensuring that each topic was equally represented.

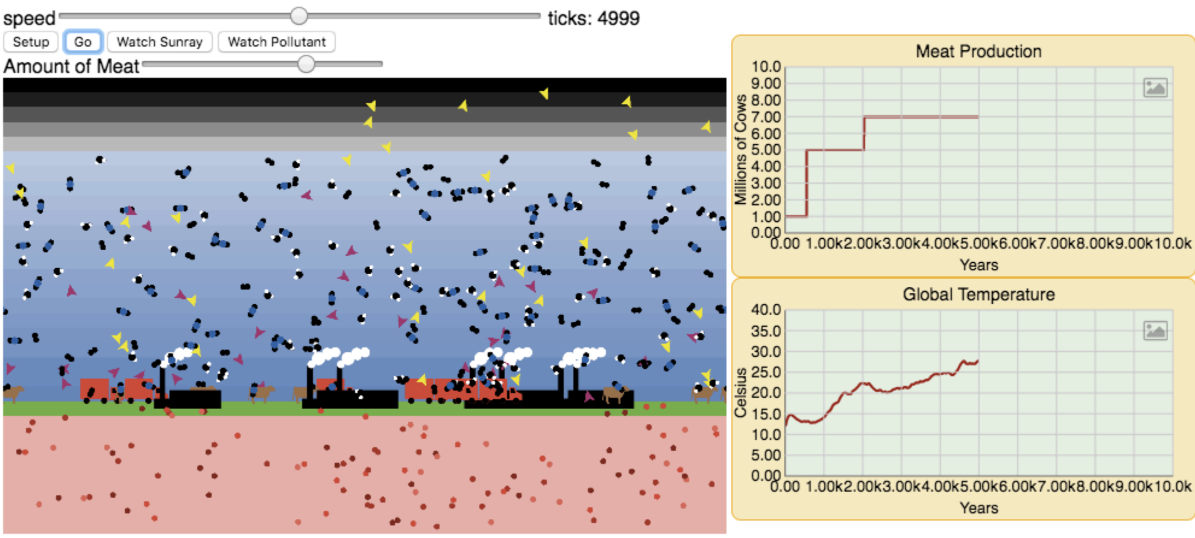

Figure 1. Snapshot of meat-eating investigation model.

To start their investigations, students saw a computer model that matched their topic (see Figure 1 for a snapshot of a meat-eating model). After exploring the model, students generated research questions that could be answered using the model. Once students selected their research question and explained the data they would need to answer their question, students gathered their data using the computer model. Computer model exploration was followed by reflection prompts about their investigation and their findings.

Collaborative jigsaw activity

After completing their investigations and reporting the results of the findings within WISE, students participated in a jigsaw activity. During the jigsaw activity, students were placed in groups of six (two students from each topic). Students were asked to present the findings of their investigations to their group members.

Assessments

At pre- and posttest students were asked 3 questions relevant to the challenge (one question for each topic). For meat-eating: *Suppose everyone on earth started eating twice as much meat as they do now. Would that make earth's climate colder, hotter, or have no effect? Explain your reasoning.* For albedo: *Suppose we covered the Earth's land with giant mirrors. Would that make earth's climate colder, hotter, or have no effect? Explain your reasoning.* For ozone: *Does the ozone hole make earth's climate significantly colder, hotter, or have no effect? Explain to* [fictional character name] *the role of ozone in global warming.*

Coding

Scoring (1-5) was completed using knowledge integration rubrics (Liu, Lee, & Linn, 2011). Knowledge integration acknowledges the diverse set of ideas that students hold. Without penalizing for alternative ideas, the knowledge integration rubric focuses on the links between two ideas and awards higher scores for not just stating normative ideas but also linking them together. Links for each item can be found in Table 1.

Table 1: Links for each assessment item

Pre-/Posttest item	Link
Meat-eating	Cows/trucks/factories release greenhouse gases AND this leads to higher temperatures
	Greenhouse gases reflect infrared radiation AND this leads to higher temperatures
Albedo	Mirrors reflect solar radiation AND this leads to lower temperatures
	Mirrors prevent infrared radiation from transforming into heat beneath the earth's surface AND this leads to lower temperatures
Ozone	Ozone protects us from UV rays AND this does not affect temperature
	The amount of ozone can increase or decrease AND this does not affect temperature

Major findings

Overall

Students at pretest held, on average, non-normative or incomplete ideas about the effects of meat-eating, albedo, and ozone on global temperatures (meat-eating: M=2.21, SD=.61; ozone: M=2.07, SD=.50; albedo: M=2.54, SD=.90). By posttest, student scores were higher on all items (meat-eating: M=3.20, SD=.97; ozone: M=2.88, SD=.94; albedo: M=2.94, SD=1.11). The differences between pre- and posttest scores were significant for all questions (meat-eating: M=.99, SD=.99, t(247)=15.85, p<.001; ozone: M=.81, SD=1.07, t(236)=11.62, p<.001; albedo: M=.40, SD=1.21, t(249)=5.35, p<.001). See Figure 2 for average assessment scores by question.

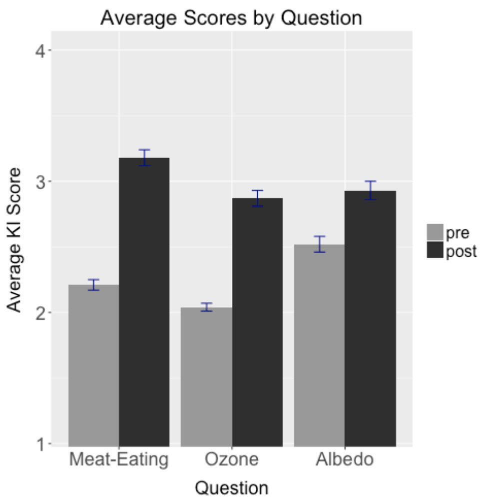

Figure 2. Average scores by question.

How does the investigation affect student performance?

Recall that students had direct experience with only one of the investigations before learning from their peers and that they were responsible for explaining their findings to their peers. Therefore, we ask: is student performance better for the item matching the investigation the student conducted themselves? In order to answer this question, we conducted a mixed effects regression with random effects for student and fixed effects for pretest score (totaled across all three pretest items), teacher, and dummy variables for whether the investigation the student conducted matched the assessment item. (See Figure 3 for posttest score averages by investigation.) Pretest score significantly predicted posttest performance (β=.19, p<.001), as did teacher (students in teacher A's class performed significantly better than students in teacher B's class: β=.21, p=.01). The effect of the meat-eating investigation was significant (β=.52, p<.001), which suggests that students who chose the meat-eating investigation performed significantly better on the meat-eating posttest item than those students who conducted a different investigation. There were no effects for either of the other two investigations on posttest performance (albedo: β=-.007, p>.1; ozone: β=.11, p>.1).

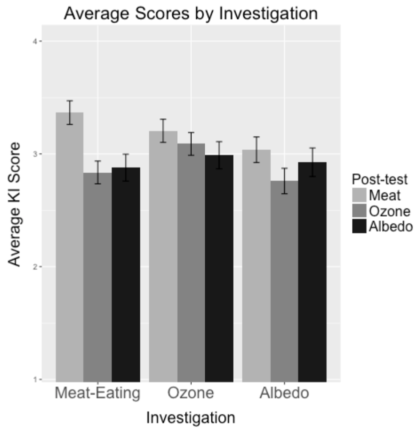

Figure 3. Average posttest item scores by student investigation.

Conclusions and implications

Study results show that regardless of investigation choice, students made gains on all assessment items. This suggests that the jigsaw activity performed one of its main functions: to help students integrate knowledge from a diverse range of ideas, regardless of their investigation choice. This provides evidence that students learned from their own investigation and from peer descriptions of the other investigations. Interestingly, students in the meat-eating investigation seemed to become "experts." The advantage for the meat-eating investigation may, in part, be due to differences in relevant prior beliefs. At pretest, students had little prior knowledge regarding meat-eating (e.g., "Why would meat effect the Earth's climate", "eating meat has nothing to do with temperature"). On the other hand, regarding albedo, students often (correctly) recognized that surface reflectivity decreases temperatures. Conversely, for ozone, students often (incorrectly) implicated ozone depletion in climate change. The extent to which investigations provided evidence that was surprising or conflicted with prior beliefs likely impacted the effectiveness of collaborative groups. For example, it might be the case that having little prior exposure or intuition around the role of meat-eating and temperature made the simulation particularly salient as they discovered something novel, whereas the discovery that ozone does not impact climate change is potentially less striking, and may be equally-well conveyed through discussion.

Overall this study suggests that simulation-based jigsaw activities can confer learning benefits to students who engage with the simulation directly and to students who learn from their peers. These results are promising given the affordances of simulations in modeling complex phenomena such as climate change.

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Evaluating the Distribution of Students' Contributions in Theorizing: Idea Evenness in Knowledge Building Communities

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Abstract: Asymmetric collaboration in CSCL environments may lead to exclusion of some students and less idea diversity than needed for a productive, inclusive community. To uncover the degree of asymmetric collaboration, the social entropy index (the sum of relative participation proportions of each individual) was adopted in some studies, but only quantitative indicators (e.g., the number of characters) were considered in the measurement. In this study, we define participation evenness plus the dimension of the quality of students' notes as "idea evenness". Adopting the entropy and using the depth of understanding within students' theorizing notes as the parameter, we analyzed the idea evenness of five Knowledge Building communities. We found that the idea evenness values are high in four of the communities and can reflect the different distributions of students' depth of understanding in different communities. The results indicate that students participated in theorizing evenly in most knowledge building communities.

Introduction

Knowledge Building aims to facilitate students to work on real ideas and address their authentic problems by taking collective responsibility (Scardamalia, 2002). By joining efforts, people may achieve something new that could only emerge as a result of their interactions (Broadbent & Gallotti, 2015). Therefore, ensuring an environment for these interactions to happen is of vital importance. One of the negative factors that may harm students' interactions is participation inequality, which refers to the phenomenon that a tiny minority of users accounts for a disproportionately large amount of community content and other activities (Nielsen, 2006). For example, the "free rider" phenomenon (Burdett, 2003) and the perception of an asymmetric collaboration among teammates (Capdeferro & Romero, 2012) were identified as frustrating things by the students who participate in online Computer-Supported Collaborative Learning (CSCL). Egalitarian collaborative systems are the preferred future organizational form (Brafman & Beckstrom, 2006). In line with the Knowledge Building goal of re-creating schools as knowledge creating organizations, symmetric knowledge advancement is highlighted in Knowledge Building (Scardamalia, 2002).

Therefore, it is of great importance to study and measure with appropriate methodologies the manner that students distribute contributions, the extent to which uneven contributions occur in online collaboration, and furthermore, how uneven contributions may influence students' knowledge building. The social entropy index has been proposed as a possible approach for understanding system-level evenness (e.g., Bruno, 2010; Matei et al, 2006; Matei, et al., 2015). Mathematically, the normalized social entropy index is the sum of relative participation proportions of each individual divided by the log of the total number of people. It was derived from Shannon's Theory of Communication (Shannon & Weaver, 1998). The idea is that in the realm of communication all symbols are equally likely to occur if they are only decided by chance, just as all atoms are likely to be in a random state in physical systems (Shannon & Weaver, 1998). The opposite is that the more organized the system is, the lower the entropy will be. Matei et al. (2010) proposed that human affairs can be understood as atoms or symbols, and individual's contributions would not be greater than chance can predict in a purely random and unstructured state. In this situation, the social entropy of this group is maximized. However, when a group is structured (i.e. when members take on some specific tasks, interact with others in a preferential manner, or contribute more or less than chance can predict), the social entropy starts to decrease. Bruno (2010) measured the participation evenness of 25 wiki groups, and the number of characters that students contributed were utilized as the parameter. He found that there is a curvilinear relationship between participation evenness and learning outcomes, and an optimal level of evenness which was close to the high spectrum exists (see figure 4 in Bruno, 2010, p109). Adjusting the entropy to the scale of 0 to 1, it seems the optimal level ranges from 0.85 to 0.95. The results may somehow imply the optimal level evenness of knowledge building community although the study was not directly conducted in knowledge building communities.

Although the quality of students' contributions plays a significant role in a community, it is not considered in the evenness measurement (Biuk, Kelen, & Venkatesan, 2008). In this study, we added the dimension of the quality of students' ideas to the participation evenness and define the variable as "idea evenness" – the sum of individual's relative apportionment of ideas (both quantity and quality) divided by the log of the total number of people.

In this exploratory study, we aim to investigate the value of idea evenness in five cases of Knowledge Building communities to see how idea evenness reflects the distribution of students' contribution in community level. This study may serve as an initial attempt to understand idea distribution in a community level and to help reveal the relationship between idea evenness and learning performance. In order to evaluate the quality of students' contributions, we employed the "epistemic complexity" and the "scientific sophistication" measures, proposed by Zhang, Scardamalia, Reeve, and Messina (2009). The epistemic complexity of ideas indicates students' efforts to produce theoretical explanations and elaborations of phenomena and the ideas that their community works on. The scientific sophistication dimension assesses to what extent students move from an intuitive to a scientific understanding.

Methods and data analysis

Secondary data analysis consisted of 1209 notes posted in Knowledge Forum – an online environment supporting Knowledge Building (Scardamalia, 2004). The notes were written by Grade 1 to Grade 5/6 (blended grades) students at a Knowledge Building school in downtown Toronto. In each grade, one class with about 20 students was included in this analysis. Each class worked in a communal Knowledge Forum space which was considered as an online community.

Primary analysis on this dataset was conducted by Resendes (2013) and her colleague using the "ways of contributing" framework (Chuy et al., 2011) which consists of six dimensions and 24 sub-dimensions. The six dimensions are: questioning, theorizing, obtaining information, working with information, synthesizing and making analogies, and supporting discussion. A note might fall into several dimensions that are applicable. Theorizing plays an important role in knowledge advancement (Chen, Resendes, Chai, & Hong, in press) for exhibiting students' attempts to produce original ideas, to produce and improve explanations, and to express alternative directions (Resendes, Chen, Acosta, & Scardamalia, 2013), and for underscoring students' pursuit to construct new knowledge (Carey & Smith, 1993). Therefore, in this study we will focus only on theorizing (i.e. proposing an explanation, supporting an explanation, improving an explanation and seeking an alternative explanation) notes. All the theorizing notes were coded using epistemic complexity scale (1 = unelaborated facts, 2 = elaborated facts, 3 = unelaborated explanations, and 4 = elaborated explanations) and scientific sophistication scale (1 = pre-scientific, 2 = hybrid, 3 = basically scientific, and 4 = scientific). The overall agreement was 81.65% for epistemic complexity and 82% for scientific sophistication. With regard to a note, a composite score by multiplying the epistemic complexity score and the scientific sophistication score was considered as its depth of understanding (Zhang et al., 2009). For each student, the composite scores of his/her notes were added up, and the total score was used as the parameter to calculate the idea evenness of this community.

Using each student's share of depth of understanding, idea evenness was calculated using the normalized social entropy formula in each class separately. To better understand the essence of the social entropy index concept, we would paraphrase how Matei et al. (2010) discussed it in computer-mediated collaboration environment:

Suppose in an online community space (M), there are m students who contribute n notes in total (a note only belongs to a student). Let C be a set of each student's notes.

$$M = \{M1, M2, \ldots Mn\},\ C = \{C1, C2, \ldots Cm\}, \text{ then } C=M$$

Si the ith student's share (mathematical proportion) of notes in the note space M.

$$Si = Ci/\sum_{j=1}^{m} Cj \quad \sum_{i=1}^{m} Si = 1$$

If we have only one participant in M, then there is no uncertainty of who posted the notes. But if we have two, a degree of uncertainty of contribution happens. For the perspective of information theory (Shannon & Weaver, 1998), there are two possible answers to the question of who posted a note, which carry 1 bit ($\log_2 2$) of information. If we have m participants, the answer to the above question will have m possibilities, which carry $\log_2 m$ bit of information.

Mathematically, the social entropy of a random variable X is defined as:

$$H(X) = -\sum_{i=1}^{m} p(x) \log_2 p(x) \text{ where p(x) represents the share of each student's contributions}$$

More participants indicate more diverse participation, the more distributed of the contributions by the students, and the higher social entropy, which may even hide the "lurker" problem. For example, the social entropy for a community with two students who contribute the same (1/2, 1/2) is 1, however, the social entropy for a community with six students who contribute (1/4, 1/4, 1/4, 1/4, 0, 0) is 2. Although the students in the first community participate more evenly, and there are two lurkers in the second community, the social entropy index for the second group is higher than that of the first group. To compare the evenness of different communities with different numbers of participants and to handle the "lurker" problem, normalization should be obtained by dividing the entropy by its maximum score $\log_2 m$:

$$H_0 = H/H_{max} \text{ where } H_{max} = \log_2 m$$

The normalized social entropy index ranges from 0 to 1. "1" means perfect evenness, while "0" denotes total unevenness.

Results and discussions

Table 1 shows the number of total notes and total theorizing notes in each class, indicating nearly half of the notes were coded for depth of understanding in each grade. Figure 1 shows 20 Grade 2 students' shares of depth of understanding, while figure 2 shows 20 Grade 3 students' (not the same 20 students in Grade 2) related shares, indicating grade 2 students theorized in an evener manner than that of grade 3.

The results of the social entropy measurement are shown in table 2. Except for Grade 3, the idea evenness values of other grades seem to fit the optimal level according to Bruno (2010), indicating that students' depth of understanding in theorizing is distributed in an even and desirable manner in these Knowledge Building communities. However, it should be noticed that the optimal entropy level (Bruno, 2010) was achieved through undergraduate students' wiki participation and only quantitative indicators were used as the parameters. We need to be careful with the generalization of the results.

This idea evenness for Grade 2 is much higher than that of Grade 3, which indicates that the depth of understanding of Grade 2 students' theorizing notes distributed more evenly than that of Grade 3 students'. Also, from figure 1 and figure 2, we noticed that in Grade 3, several students (S5, S11, S17) did not contribute in theorizing, and some students contributed much more than the other students, for example, the depth of understanding in S6's and S7's theorizing notes is significantly higher. The idea evenness values of the two classes reflect this kind of different distributions of depth of understanding.

Table 1: The description of the number of total notes and total theorizing notes in each class

Number	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5/6
No. of notes	370	121	141	272	305
No. of theorizing notes	189	86	66	125	167

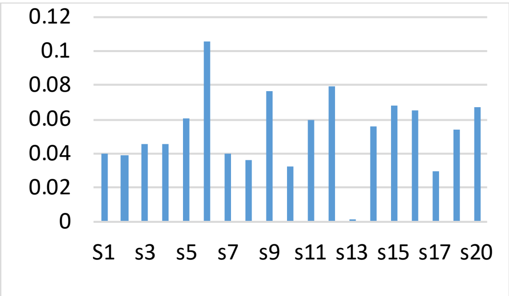

Figure 1. Grade 2 individual share of depth of understanding.

Table 2: The value of idea evenness in each grade

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5/6
Idea evenness	0.88	0.95	0.73	0.89	0.88

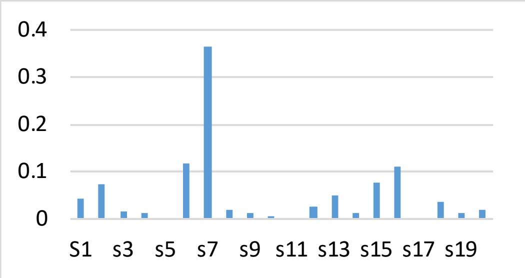

Figure 2. Grade 3 individual share of depth of understanding.

Conclusions and future directions

In this study, we examined students' idea evenness in knowledge building communities by adopting the normalized social entropy measurement. Each student's total score of depth of understanding of theorizing notes was used as the parameter. We found that except for Grade 3, the idea evenness values in other grades are relatively high. Also, the idea evenness values reflect the different distributions of students' depth of understanding in different grades (e.g., Grade 2 and Grade 3). The results indicate that students participated in theorizing evenly in most knowledge building communities, and the social entropy index can be used as an indicator of the distribution of students' contributions.

In this exploratory study, we only considered students' theorizing notes, given the importance of theorizing in knowledge advancement (Resendes et al., 2013). The next steps will be taking all notes posted online and face to face into consideration, and adding more qualitative indicators, for example, ways of contributing (e.g., original idea creation, connecting ideas, and critical appraisal), collective responsibility (at an individual level, intergroup level, and intragroup level) and so forth to the idea evenness measurement. Another issues worth studying is that right now, if one student contributes more notes, it may compromise the undesirable quality of his/her notes. Moreover, the relationship between entropy and students' learning performance needs to be studied specifically with rich knowledge building communities, and the results may inform a teacher how will the level of entropy in his/her class influence students' knowledge building and if he/she should take actions to address the idea unevenness issue, if exists.

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Developing Professional Competency in a CSCL Environment for Teamwork: Two TPACK Case Studies of Teachers as Co-Designers

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Abstract: Teachers play an important role as co-designers in the development of learning interventions in blended CSCL environments. However, when new pedagogy and technology are introduced, it may not be easy for teachers to thrive in such complex environments. It is therefore important to identify key knowledge bases required for teachers to teach effectively in new CSCL environments. Using the lens of Technological Pedagogical Content Knowledge (TPACK), the paper will examine two case studies of teachers who co-designed a CSCL tool for teamwork with a research team and implemented it in their classrooms. The paper reveals the interacting components of technology, pedagogy and content knowledge, and highlights strengths as well as growth areas for the teachers' further professional development. Through identifying and then building these knowledge layers, teachers will be able to harness tools and co-design proficiently and successfully in technological environments.

Introduction

Teachers play an important role as co-designers in the development of learning interventions in blended CSCL environments. Teachers not only provide the authentic realities of the classroom and the workable designs for the curriculum, they also implement the lessons and adapt the CSCL environments accordingly. Teachers have firsthand contextual understanding of student backgrounds, school curriculum requirements and even educational policies. However, in the process of making these pedagogical changes, teachers, as with all learners, have their own trajectory of growth and change. Teachers may feel challenged in different areas as they leverage affordances of the CSCL environments for teaching and learning, such as the use of the technological tool or in the teaching of content. Especially when new pedagogy and technology are introduced, it may not be easy for teachers to harness the affordances of new CSCL environments. It is therefore important to identify key knowledge bases required for teachers to teach effectively in these new environments. In technological environments, the Technological Pedagogical Content Knowledge (TPACK) framework is an established lens to illustrate the content, pedagogy, and technology knowledges as well as their interactions (Mishra & Koehler, 2006). It recognizes that teachers face complex issues in the blended learning classroom and seeks to make known the knowledges and skills that teachers should have in order to thrive in these environments. TPACK has been used in many ways such as for teaching teachers and developing courses (Tokmak et al., 2013), and in the analysis of teacher practices (Powell et al., 2015) in technology integration.

In a similar manner, this paper will utilize TPACK to draw out crucial knowledges and practices in one such CSCL environment. Besides connecting the CSCL tool with teaching practices, the TPACK lens also helps to identify needful areas for further professional development. In this paper, our research context involves a CSCL tool, My Groupwork Buddy (MGB), which was co-designed with a team of teachers, researchers, and web developers, in order to help students grow their teamwork competency and also to enable teachers to deepen their professional competency in teaching and facilitating teamwork competency in students. This paper reports on the first year of the project and focuses on the teacher enactments and adaptations of MGB in the classroom. Specifically, using the TPACK lens, we will examine the teacher practices of two cases of teachers from two different schools and classrooms. We ask, to what extent do teachers show professional competency (TPACK) in teaching and facilitating teamwork competency with MGB?

Technological Pedagogical Content Knowledge

TPACK arose from Shulman's (1986) research on pedagogical content knowledge (PCK) required for effective teaching. Shulman argued that successful teachers possessed PCK, which is a specialized form of knowledge that combined particular understandings and knowhow about teaching the content matter. Mishra and Koehler (2006) subsequently extended the work for technological contexts to include technological knowledge and how all these knowledges interact. In essence, TPACK has three foundational forms of knowledge: technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK). Notwithstanding, intermediate forms of knowledge are also needed; these are the interacting knowledges: technological pedagogical knowledge (TPK), technological content knowledge (TCK) and pedagogical content knowledge (PCK), and technological pedagogical content knowledge (TPACK). Particularly, TPACK recognizes that a deep understanding of all three types of knowledges is needed in order to integrate and teach effectively in technological environments.

The CSCL tool and environment: MGB

MGB is developed as part of a larger 2.5 year project using a design-based research approach to grow students' teamwork competency. Technically, it is a Single-Page Application with a student team chat, lesson pages, student rating and teacher monitoring features. Pedagogically, it is underpinned by the Team and Self Diagnostic Learning (TSDL) Pedagogical Framework which is grounded in key theories such as experiential learning and the learning analytics process model (Koh et al., 2016; Kolb, 1984; Verbert et al., 2013). The TSDL employs a four stage cycle: (1) immersing students' in concrete collaborative experiences, (2) building students' awareness of their teamwork competencies primarily through self and peer teamwork ratings, (3) engaging students in reflection and goal-setting, and, (4) monitoring students' teamwork competency changes. The project has also developed a measure for teamwork consisting four teamwork competency dimensions: coordination, mutual performance monitoring, constructive conflict, and team emotional support (Refer to Koh et al., 2016 for more details).

TPACK and MGB

Adopting the TPACK lens, we will analyze the teachers' knowledges and skills in the CSCL environment. Specifically, we will refer to teamwork as the content matter, MGB as the technological environment, and TSDL as the pedagogy. Each component of TPACK is elaborated below:

- CK: knowledge about teamwork concepts, i.e., teamwork dimensions.
- PK: knowledge and skills in applying teamwork strategies, facilitation strategies of group work, group discussion and reflections (both individually and team based), notably the TSDL framework.
- TK: knowledge and skills about the use of MGB, its affordances and constraints.
- PCK: knowledge and skills of how to apply TSDL to teach particular teamwork dimensions (content).
- TCK: knowledge and skills of representing teamwork concepts in MGB.
- TPK: knowledge and skills of how to use MGB with respect to the pedagogy of TSDL.
- TPACK: knowledge and skills of teaching and facilitating teamwork with MGB using TSDL.

Methodology

A case study approach is employed to address the research question. This provides a richer understanding of the use of the CSCL tool by the two teachers. Qualitative data pertaining to the teachers during the first year of co-designing and implementation was collected. The data sources are: lesson observations (including field notes of lessons and photographs and/or videos taken during lessons), teacher prepared slides (including modifications made by teachers from the researcher prepared slides), teacher email interviews, and meeting notes from face-to-face meetings between teachers and researchers. The data was thematically coded according to the TPACK lens for each case. This was followed by a cross-case analysis with iterative discussions by the authors to draw out the larger themes.

Study background: Case A and B

During this first year, two different teachers from two different co-ed Secondary schools were involved in implementing this project, teacher A and B. In both cases, the research team had several meetings with the teachers before the implementation to co-design the use of the CSCL tool in the curriculum specific to their schools. During the school term, the research team also touched base with each teacher at appropriate junctures to support the teacher's implementation.

Case A

Teacher A teaches the subject, Design and Technology, where student teams have to create a physical prototype of a useful device for a welfare organization. This project was 1 year long, and the teacher was observed for key lessons throughout the year, for the four terms. Two classes of 14 year old students were involved in the project. Teacher A is also the ICT subject head, and has been in this position for 4 years, having previously been a teacher for 6 years. He is a subject specialist, and not the students' form teacher.

Case B

Teacher B teaches the subject, Integrated Project Work, which is an inter-disciplinary subject combining Geography and English. This subject also emphasizes collaborative learning. Student teams have to complete a series of investigations related to water and one of the final outputs was the creation of a product or activity to highlight the issues of water shortage and water conservation. This project was 6 months long (Term 3 and 4), and the teacher was observed for 6 lessons. One class of 13 year old students was involved in the project. Teacher B was a relatively new teacher with 3 years of experience. This was the first time she was teaching this subject at Secondary 1. She is also the students' form teacher.

Analysis

Table 1 provides the individual and cross-case comparison.

Table 1: TPACK of the two cases.

	Teacher A	Teacher B
CK	Took some time to learn what the 4 teamwork dimensions are. But could explain them well at Term 4 with examples.	Took some time to learn the 4 teamwork dimensions. By the end of the 6 months, could explain the dimensions briefly but got mixed up at times, and the dimensions were not understood at a very deep level.
PK	Is familiar with teamwork awareness but not the reflection aspect. Utilizes the design thinking approach in his pedagogy.	More comfortable with facilitation of group work in the classroom as compared to the computer lab (the latter point will be addressed in TPK). Taught in a structured way to scaffold and guide students to produce "good reflections"
TK	Very knowledgeable. Uses technology pervasively in classes. Very comfortable using ICT to teach.	Keen to use and explore the affordances of MGB.
PCK	Thought about the delivery of the lesson, created and modified slides to suit the implementation. However, did not hold tight to the "product" aspect of the reflection, but approached it more as a process. Warned students that they might have to stay back if they did not do the activity properly, although this was just once.	Reflection is treated as one of the "products" of learning, used for summative assessment. Therefore, the teacher scaffolded and explicitly taught students how to reflect and write reflections.
TCK	Understood teamwork concepts in MGB and proactively instructed students to write specific and timely targets for their teamwork goal-setting (personal and team).	Used MGB to monitor students' individual and team progress.
TPK	Some aspect was developed such as knowing how to get students to rate self and peers. During the teamwork reflections, the teacher emphasized the process, informing students to "refine" reflections where necessary. A similar approach was adopted for the goal-setting. However, this teacher did not use MGB to help monitor students' teamwork. He was not sure how serious students would be toward responding to the activity.	Faced difficulty in classroom management at the computer lab, compared to the classroom. Was not able to use the curriculum time efficiently, resulting in students having to wait and not being engaged when instructions were given. When facilitating the reflection on the system, emphasized that students can "re-do" their reflections if they did not do it well the first time.
TP-ACK	As a whole, generally competent by Term 4. Also, from the start of the implementation emphasized the total integration of MGB in the curriculum. "When students think of the subject, they should think of MGB".	Competent but viewed MGB from summative assessment lens and an add-on to the curriculum instead of integration.

Discussion and conclusion

Bearing in mind the contextual differences of the two cases, our cross-case analysis illustrates learning challenges and differing trajectories for both teachers as they embark on the process of co-designing and implementation. Both teachers had gap areas of knowledges which were subsequently shown to be picked up as the project went on. Though it took them a while to learn the four teamwork dimensions and use the right terminology in their lessons, both teachers were able to explain the dimensions to their students by the end of the project. However, this was weaker in Teacher B; her understanding of teamwork could be deepened.

When there is wider misalignment of TPACK understanding, we found the teacher experiencing a steeper learning curve. For example, though both teachers were familiar with the use of technology for teaching (TPK), Teacher B was less adept at orchestrating a class of 40 students to use the system in the computer lab, resulting in some time loss due to classroom management issues. This can be attributed to her lack of knowledge and experience and highlights an area for further professional development.

Interestingly, in the same CSCL environment, different practices were exhibited by teachers in the co-designing process. Teacher A was proactive in giving suggestions to improve MGB while Teacher B focused on harnessing the current affordances of the existing tool e.g., tracking and monitoring students' progress and working as a team.

Although both teachers followed the TSDL framework, their PCK and TPK showed different teaching emphasis, which also reveals their teaching beliefs. Teacher A is more focused on the process of the activity, while Teacher B emphasized the product of the artefacts created by students during the activity. These two emphases have their own strengths and weaknesses. More importantly, both approaches meet the needs of the teachers employing them, as teachers have first-hand and crucial contextual understanding of their classroom and the curriculum outcomes of the school. On the same note, teachers' interpretations of their own accountability and their students' autonomy, likewise influences their emphasis in co-designing and lesson implementation. In Case B, it was a focus on summative instead of formative assessment, holding students accountable for their reflections and scaffolding their learning to write reflections while in Case A it was to give students room to make changes along the way.

As a whole, Case A demonstrated greater TPACK, with the emphasis of total integration rather than separating the tool and activity from the rest of the curriculum. Nevertheless, different aspects of TPK could be strengthened such as harnessing the monitoring features of MGB. For Case B, while there are several gap knowledge areas, we acknowledge that this teacher had less time to develop her professional competency. Giving the teacher time and support with relevant TPACK training would help her trajectory of growth.

The TPACK lens has been useful for identifying the areas of challenges and growth in the two cases. This systematic approach helps to highlight areas in which the research team can provide greater professional development support and enhance the design of the CSCL tool. This recognition of the interacting components of technology, pedagogy and content knowledge testaments to the complexities that teachers face in effective technology implementation. Yet, through building these knowledge layers, teachers will be able to harness tools and co-design proficiently and successfully in technological environments.

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Collaborative Argumentation During a Making and Tinkering Afterschool Program With Squishy Circuits

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Abstract: This study investigates how young children engage in collaborative argumentation during Making and Tinkering (M&T) afterschool program using Squishy Circuits. Two perspectives guide the work: constructionism to explore M&T practices and everyday argumentation to explore the ways peers support each other in collaborative argumentation. The video-based study was conducted during an hour-long afterschool learning sessions over three weeks. Episodes of learners' collaborative argumentation practices were analyzed by examining talk, body formation, gestures, and tool handling. The findings expand current research on argumentation by describing and characterizing the collaborative argumentation practices that occurred during M&T. Findings also contribute an understanding of collaborative argumentation as a theoretical framework to expand constructionism.

Emerging research suggest that at a young age, children can engage in argumentation (Monteira & Jiménez-Aleixandre, 2016; Siry, Ziegler, & Max, 2012). Young children's argumentation includes purposeful observation (Monteira & Jiménez-Aleixandre, 2016), evidence construction, and theory formulation (Manz, 2016). Most science education argumentation findings are from classroom contexts where teacher support is available; less is known about argumentation practices in informal spaces with peer support. As such, our study focuses on collaborative argumentation practices during a Making and Tinkering (M&T) afterschool program by investigating the question: what are the ways that peers support each other in collaborative argumentation?

Theoretical framework: Constructionism and everyday argumentation

We use constructionism (Papert & Harel, 1991) as a lens to explore children's M&T activities. Constructionism builds on constructivism in which knowledge is not transmitted, but rather is constructed from personal experiences. Physical artifacts that are created and accessible during construction become "objects-to-think-with" to support learners to make connections as they build new knowledge (Kafai, 2006, p. 39). We seek to expand the theory of constructionism with the addition of a second lens, collaborative argumentation.

Collaborative argumentation is dialogical (Baker, 2002). Prior studies have highlighted the importance of collaborative sense-making (Zimmerman, Reeve, & Bell, 2010) as well as different social modes of co-construction and communicative approach that support or hinder the argumentation practices in science classrooms (Jiménez-Aleixandre, 2007; Weinberger & Fischer, 2006). Yet the field of education needs to know more about the manner in which learners engage in collaborative argumentation in out-of-school time settings. Bricker and Bell (2008) argue that research has failed to consider what everyday argumentation practices and competencies learners bring with them to new learning experiences. They have shown that youth's everyday argumentation shares great similarity to scientific argumentation practices. Building from an everyday perspective on argumentation, we seek to understand how children's collaborations in M&T are dialogically constructed through appropriation of their everyday practices and competencies.

Methodology

This study took place at an elementary school in the northeastern region of the United States. A 3-week afterschool program was developed around understanding the concept of circuitry using Squishy Circuits (Johnson & Thomas, 2010). Squishy Circuits includes LED lights, motors, buzzers, and a battery pack with two wires that can be connected to conductible Play-Doh™ to create a circuit. We chose to use Squishy Circuits because of its technological affordance to make the circuitry using Play-Doh™. We also provided iPads for small groups to collaborate with for their research and photo-documentation of the artifacts that they created.

Out of 48 children in the afterschool program, seven children who were interested in the topic consented to be in our study (8-9 years; 3 female). The two male children had previous experience with Squishy Circuits. The researchers were both observers and participants. The seven children were video-recorded for three weeks. Fieldnotes were taken during and after each session. Pictures of Squishy Circuit models and idea sketches were collected. Given that all modes of communication are used in argumentation, the analysis was guided by Goodwin (2007)'s embodied participation framework, paying particular attention to how argumentation is achieved through spatial and body formation as well as tool handling. Analysis followed methods of both conversation analysis (Ochs & Capps, 2009; Schegloff, 1991) and interaction analysis

(Erickson, 2004). First, content logs (Jordan & Henderson, 1995) were created and then analyzed along with ethnographic fieldnotes. Adopting Baker (2002)'s definition of argumentation as "cooperative explorations of a dialogical space of solutions" (p. 306), episodes were identified where groups faced a problem in relation to building their model with Squishy Circuits. Then, we identified episodes of collaborative argumentation where learners engaged in argumentation without the support from the facilitator. Most of the episodes of collaborative argumentation occurred for a short duration, except for those that occurred during the first week. We present one of the extended episodes here from a group of girls, Elina (8 years old) and Nicole (9 years old). Their case is representative of sustained collaborative argumentation in our dataset.

Findings

Our preliminary analysis illustrates that children in our dataset supported each other to engage in collaborative argumentation through collaborative meaning-making talk and role-taking.

Everyday language supported collaborative argumentation in M&T

The collaborative meaning-making talk was developed through the appropriation of everyday language. The excerpt below starts after Elina and Nicole engaged in a challenge to make one LED light up. They decided to make an alien with two illuminated eyes. Their plan to light two LEDs in one structure of Play-Doh™ was an impossible task without the use of insulating dough. As they continued to struggle, the researcher shared two principles: 1) a circuit needs two pieces of dough, and 2) the longer lead of the LED has to be connected to the dough that is connected with the red wire of the battery pack. The researcher shared the metaphor of LED having the "right shoes" to explain the concept of polarity and suggested flipping the LED when it does not light up. The episode presented below starts at Nicole and Elina's first attempt to light one LED after the circuitry principles had been explained by the facilitator.

01	Elina:	((to researcher)) Well this might work now, because I turned it around.
02	Researcher:	Right. Notice-
03	Nicole:	((looking at Elina and back to researcher)) But it has to be two different things.
04 05	Researcher:	Notice how… Right exactly. Nicole just said something really important. There has to be two different things. Two different pieces of Play-Doh™.
06	Elina:	((keeps looking down at her Play-Doh™))
07	Nicole:	((makes a little phone with Play-Doh™)) So this could be a phone for it.
08	Elina:	((looks up at researcher)) Oh! So it needs something for the alien.

After sharing of principles of circuitry, Nicole soon noticed that the problem with their model was due to only having one piece of Play-Doh™ (line 3). However, Nicole's explanation did not trigger any reaction from Elina. Elina was deeply engaged in making the model that she hardly glanced away from the Squishy Circuits model (line 6). What was a pivotal moment for Elina was to see that the alien model could now have a phone to act as a second piece of Play-Doh™ (line 8). This moment of realization was supported by Nicole's use of everyday making vocabulary such as "a phone for the alien" (line 7). The researcher had highlighted the importance of having a second piece of Play-Doh™. However, the scientific explanation of how circuits work did not cause any change of action from Elina until Nicole re-framed the scientific explanation in relation to their alien model. When a solution was offered in everyday language (not in scientific terms) — grounded to the features of their model — Elina understood the circuitry concept. This episode highlights the importance of children's everyday language in developing the collaborative meaning-making talk during argumentation in M&T.

Role-taking in support of developing a collaborative argumentation

Our analysis of the videorecords also showed that peers' role-taking supported them to initiate and sustain their engagement in collaborative argumentation. We found evidence that Nicole and Elina engaged differently in argumentation practices of identifying problems, offering solutions, and engaging in the trial-and-error spirit of M&T as they took on different roles. Findings showed that their different ways of engaging in argumentation influenced each another to create a model that was functional and also aesthetically pleasing. The excerpt presented below is a continuation of the previous from above.

01	Nicole:	How about a phone? ((brings the phone in front of Elina's face))
02 03	Elina:	Ok, a phone, hehe. But I am making it more exotic. ((pinches wire into the phone))
04	Nicole:	((turns the battery on)) Ok, let's just plug it in ((grabs the wire)). Wait and then

	one, we only need one ((takes one LED out)), one eye ((puts LED to phone)).
Elina:	Oh, one eye, ok…That looks really weird.
Nicole:	We need it… ((brings the LED that is in the phone near to the alien to connect))
Elina:	No. I know we could make this the eyes and then we could make this the nose ((puts LED in as a nose and makes marks with fingers to create eyes)).
Nicole:	But we need this to stick into like... ((makes gestures))
Elina:	Look ((raises the model in the air))! There's the eyes and there's the nose!
Nicole:	((looks at the model)) And then one has to be in here ((points to the phone structure)) and one has to be in here ((points to the alien structure)).
Elina:	Like this? ((puts one LED lead to phone and the other lead to alien structure))
Nicole:	And then turn it on ((turns the battery pack on)).
Both:	((notice that LED light is not on))
Nicole:	Switch it around. Maybe it's in the wrong shoes.
Elina:	((switches the orientation of the wire))
Nicole:	((notices the light is still not on)) Maybe it's in the wrong spot ((shrugs)).
Elina:	((Puts LED near the alien's head where the other LED light is)) Nope ((nods)).

Throughout their collaboration, Nicole and Elina identified problems, offered solutions, and investigated by trial-and-error, but they did so by taking on different roles. Nicole acted in an engineer role when she suggested that her group explore functional solutions. Nicole's discourse and tool handling were aligned to the engineering design process: progressing from identifying the problem (not having two pieces of Play-Doh™) to offering a possible solution (a phone), to testing (plugging wires and turning on), to identifying a new problem (two LEDs in one Play-Doh™ piece), to finally offering an explanation to make sense of the scientific concepts with her partner (LED leads have to be plugged into separate pieces of Play-Doh™). Elina approached the task by acting in a designer role. Elina's discourse and tool handling related to making aesthetic refinements to the model (using the wires to make the phone exotic), noticing an aesthetically unpleasing element (not having two eyes), and suggesting an alternative design (LED could be the nose).

The girls' different ways of engaging in argumentation allowed them to recognize that the engineering and design roles were both needed to build a model that was functional and aesthetically pleasing. At first, Elina did not fully attend to the functionality of the model when Nicole made attempts to orient Elina's attention to the problem of having two LEDs in one Play-Doh™ (lines 4-5). After a few conversational turns, Elina began to incorporate Nicole's suggestions in terms of fixing the model to function (line 14, 18, 20). In this regard, Elina and Nicole's different roles supported them to sustain their engagement in collaborative argumentation.

Discussion

This study's findings expand the current conceptions of everyday argumentation by illustrating how objects-to-think-with (Kafai, 2006) such as Squishy Circuits allow young children to engage in collaborative argumentation using the interactional social processes of collaborative meaning-making talk and role-taking. The Squishy Circuits models supported these two girls (and others in our study) to understand the concept of circuitry. Importantly, the M&T tools as object-to-think-with acted as a concrete artifact from which the learners could generate evidence to inform their arguments about their design solutions. The visual and tactile feedback from the Squishy Circuits model supported Nicole and Elina to test out their ideas and identify errors in their physical models, allowing them to expand their understanding of circuity. In this regard, we posit that the role of physical objects in constructionism can be extended from objects-to-think-with into objects-to-argue-with. We posit that considering M&T as a rich context for engaging in argumentation can provide an additional rationale for bringing these M&T activities to formal and informal learning environments.

Our study showed that these two young girls had a capability to support each other through the use of everyday language and role-taking. Through their everyday language Elina and Nicole made connection to scientific concepts, which has been shown by the prior work to be an important skill in-school (Siry et al., 2012) and out-of-school (Zimmerman, Reeve, & Bell, 2008). Furthermore, Nicole's support of Elina, through her shifts in gaze and body formation can be seen as similar to the supports that adults use to bring the child share the same stance towards the activity (Goodwin, 2007). Also, through emergent role-taking Elina and Nicole recognized both the value of engineering and design roles in order to build a model that was functional and aesthetically pleasing. Different roles supported them to argue for different ways of doing things, which is in resonance with Papert and Harel (1991)'s idea of two styles that are relevant to constructionism: analytic formal style and bricolage style in which the work is organized through negotiation rather than planning. Consequently, our study's finding suggest that peers can support each other with their everyday language and role-taking during M&T in out-of-school settings as part of their collaborative argumentation. As such, we highlight the importance of making space for small group conversations using everyday language to allow children to collaboratively make sense of scientific concepts. Furthermore, we advocate for designing the M&T activity in a way that learners can equally address the functionality and the aesthetics.

Implications

Our findings illuminated that collaborative argumentation during M&T may be characterized differently from young children's argumentation practices in science. Argumentation practices in M&T were targeted to finding design solutions. This solution-focus influenced the nature of children's argumentation because it allowed learners to argue for multiple solutions. Consequently, learners used purposeful observation to identify problems in M&T rather than asking questions. Evidence construction was concerned with testing the functionality of a solution in M&T instead of justifying a scientific phenomenon. Collaborative argumentation in M&T led to creating solutions instead of formulating theories. These differences lead us to advocate for recognition of engineering argumentation. We will explore the nature of engineering argumentation in future M&T studies.

This study focused on investigating the ways peers supported each other to engage in collaborative argumentation during M&T. For future research, we hope to extend our analysis to investigate how and why such collaborative argumentation occurred by studying interaction within and across multiple peer groups. Furthermore, we advocate for future research to identify argumentation practices in other fields to inform the spectrum of argumentation practices that learners can engage in. This will support informal and formal educators, as well as researchers, to understand the different types of argumentation that may support learners' sense-making — expanding the idea of argumentation across disciplines and settings.

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Participatory Design With Students for Technology Integration: Shifting Power and Organizational Practices in an Urban School

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Abstract: This paper examines how *infrastructuring* through participatory design (Le Dantec & DiSalvo, 2013) for school technology practices with students reorganized traditional power relations between students and adults, and how such shifts in power relations in turn surfaced new organizational technology practices. Two researchers collaborated with a group of high school students with a shared goal of designing school technology practices that were meaningful to the students. Informed by theories of infrastructuring forms of participatory design (Le Dantec & DiSalvo, 2013), the collaboration explicitly sought to re-mediate the social relations of designing the school's organizational practices with technology. This study analyzes the development and implementation of a student-designed school technology practice as a case study to examine how infrastructuring forms of participatory design mediated shifts in power relations and organizational practices at the school site. Results indicate that forms of participatory design which seeks to address social relations in the process and outcomes of design can contribute to shifts in student roles within the school and facilitate boundary crossing (Akkerman & Bakker, 2011) in which student goals were reflected in new organizational technology practices.

Equity as a priority for technology integration in schools

Literatures on sociotechnical systems identify the processes in which technologies enter local contexts are mediated by the broader contexts of culture, history, organizational structures, and interactions (e.g. Nardi, 1996). In varying educational contexts, digital technologies have been observed supporting student participation in social, political, educational and economic activities (Ito et al., 2013), while also reproducing barriers to such participation for traditionally marginalized students (e.g. Watkins, 2011). For example, Ito and colleagues, through research related to "connected learning" practices, have highlighted the affordances of emerging technologies to bridge student epistemologies and goals for participation and agency in broader civic, economic, and educational activities (Ito et al., 2013). Such practices are predicated on boundary-crossing processes in which new forms of educational practices are conceptualized through stakeholder knowledge and needs to make participation in capital-producing activities more accessible (e.g. Schwartz, 2015). On the other hand, many have documented ways in which access to technology-mediated activities can reproduce existing inequities based on race, gender, class, and other demographic factors (Warschauer & Matuchniak, 2010). What is often referred to as the "digital divide" can be viewed as a direct consequence of existing educational barriers that traditionally marginalized students experience. What both of these literatures suggest is that inequity is a consistent concern for technology integration in schools, and that equitable approaches to technology integration in schools must respond to the situated elements of such a process, such as organizational practices, stakeholder priorities, and power relations. This study aims to examine the affordances of particular forms of participatory design in designing localized approaches to school technology integration, and in particular, how such design methods may shift power relations in productive ways to develop school organizational practices.

Power as mediator of school technology practices

Schools are sites in which broader social inequities can be alleviated and reproduced in a number of ways (Collins, 2009). This is no different for technology integration in schools, where factors such as access, identity, and pedagogy can mediate the extent to which students benefit from the supposed affordances of emerging technologies (Warschauer & Matuchniak, 2010). As such, school organizational practices have been recognized as a key factor in successful technology integration in schools (e.g. Fishman and Pinkard, 2001). This study views the relational power between stakeholders and consequent ability to participate in the design of school technology practices as a primary constraint to the development of equitable technology practices in schools.

While power, particularly in the context of designing school technology practices is under-examined, fro ma sociotechnical perspective that assumes the social embeddedness of technological practices (e.g. Nardi, 1996), it undoubtedly plays a role in mediating the possibilities of technology integration in schools. Ladson-Billings (2006) argues that there are historical educational debts that are owed to marginalized students as a result of their continued exclusion from productive educational domains, and therefore, a purely access-based response to technology integration is unlikely to fundamentally transform the deep roots of inequity in education. One expression of such a debt is the power dynamics within schools that exclude marginalized students from shaping their own educational pathways. Nondominant students, in the context of their schools, tend to be excluded from roles that allow them to meaningfully shape the educational practices that serve them (Delpit, 2006). It is particularly problematic that students are excluded from such processes because student knowledge developed in various ecologies can become important resources for the design of technology practices as well as learning processes more broadly (Barron, 2006; Yosso, 2005). In other words, educational interventions aimed at equity in technology integration in schools should not be limited to providing access to particular tools or pedagogy to students, but should also consider how the power relations in designing school technology practices may be remediated to offer more opportunities for knowledge-sharing across stakeholders and agentic action for non dominant students. This analysis will examine the relationship between shifts in power and organizational practices in relation to student participation in the remediation of school technology design processes.

Participatory design and infrastructuring

Infrastructuring in participatory design (Le Dantec & DiSalvo, 2013), the iterative refinement of the social relations in participatory design processes, provides a useful methodological framework towards removing barriers for traditionally marginalized stakeholders to participate in design activities. Such a process reflects the original conceptualization of participatory design as an approach to workplace design in Scandinavia, which focused on the redesign of social relations between workers and management to develop more equitable work practices by leveraging insights for design that would otherwise be marginalized. As such, equity in this instance is conceptualized as both shifts in power relations for design that include the needs and epistemologies of traditionally marginalized stakeholders, and the access to practices that express the needs and epistemologies of stakeholders. Applying this approach to technology integration in schools, *the study sought to examine the affordances of participatory design infrastructuring in developing equitable school technology practices.* While engaging youth in research and design is not a unique endeavor (e.g. Kirshner et al., 2005; Druin, 2002), more needs to be understood about how student participation shifts power relations and design outcomes in schools.

Research questions

With the need to better understand how student participation in school technology design might mediate shifts in a school's design and technology practices, this paper asks the following research questions:

1. How did social infrastructures of design shift within a participatory design effort aimed at co-designing school technology practices with students?
2. How did emerging social infrastructures for design shift power dynamics in the development of technology practices in their school?
3. How did the design outcomes and implementation of participatory design with students expand access to school technology practices that reflected student expertise and needs?

Methods: Participatory design research

Study site

The site, with 80% Latino and 14% Asian students, and 55% of students classified as "Limited English Proficient", reflected broader challenges of technology integration across urban schools. It had recently acquired a learning software named Schoology, an online Learning Management System (LMS) as well as hardware such as Chromebooks and Apple computers, gradually transitioning to a 1-to-1 laptop to student ratio. Such investments were met with inconsistent practices and uncreative use due to the lack of training, buy-in, and coordination across the school stakeholders. Students had indicated that these new tools were mostly used for submitting assignments, receiving grades, and taking quizzes.

Participatory design

Responding to the school site's needs, the authors of this manuscript recruited an advisory class of 15 high-schoolers and their advisory teacher to initiate a participatory design research project (Bang & Vossoughi, 2016) during the 2014-2016 school years to address school technology practices. Participatory design efforts in education seek to collaboratively re-mediate educational practices by addressing the sociocultural aspects of a problem space, including political and institutional dimensions of the design work (Bang & Vossoughi, 2016).

We concluded that taking on this collaborative approach to design and research will allow us to directly address issues of power by privileging the voices of nondominant students to shift their roles within the school. The group met once a week to design interventions to make technology use at the school better reflect student needs. In its second year, the program moved to an after school space with an added emphasis on students to engage with their own personal interests. The students gradually transitioned to a new group of 12 students who continued the collaborative design work.

Data sources and analysis

For this analysis, one student-proposed shifts in design processes was examined to understand how the implementation of the interventions addressed shifted the role of students within the school, and how such a shift created opportunities for organizational learning. Therefore, the interventions, and subsequent field notes describing the implementation were qualitatively analyzed for their contribution to each aspect of the equity framework.

Results

Case study: Making the collaborative design effort more passion-driven

Shifts in design infrastructure

At the beginning of the second year of the participatory design work, four students from the original design group met with the first author to discuss potential improvements in the way students engaged with the partnership. The first year had concluded with a professional development (PD) session organized by the students with administrators, teachers, and university researchers as an audience that reflected the first year's design goals that were co-developed by the researchers and students. The design goal of the first year was to develop practices that were meaningful to students using Schoology, a learning management system (LMS) that the school had recently purchased. Consequently, at the PD session, students presented their designs which all utilized the new LMS, such as an ePortfolio system to facilitate more holistic evaluation of students, an archive of "college-going interviews" of seniors to make college-going knowledge more visible, and an introduction to the "calendar" feature on the LMS. However, about five students had lost interest in the design work through the first year, and did not present at the PD session.

At the onset of the second year of the partnership, five students from the original group who had volunteered to offer feedback on the first year's collaboration met with the first author with the goal of articulating ways to improve the design methods. Asked why some students seemed to become disengaged from the previous year's work, the students unanimously agreed that the design goal, to develop "school practices" was too limiting, and that students needed to do work that they felt "passionate" about. As a result, the group decided to ask future participants to initiate their involvement by engaging with an issue or activity they felt passionate about, and use digital tools to more deeply engage with their passions with an eye towards using the outcomes of this work to inform teachers of technology practices that are meaningful to students. With engaging in "passion-driven work" through digital technology as a central thrust of the design group, the collaboration moved to an after school space with a mostly new group of twelve students who each initiated various technology-mediated, passion-driven projects, such as creating an e-sports (gaming) community, continuing the development of an ePortfolio system, and building a financial literacy website.

Power

Students who engaged in passion-driven designs emerged as leaders and experts within their particular interest-driven communities. For example, a group of students who founded an e-sports community hosted several gaming events which they planned, advertised, facilitated, documented, and were attended by dozens of their peers. They continued to expand the scope of their work to consider social issues such as gender disparities in the gaming community, as well as create extramural networks with outside gaming experts such as several university-based gaming communities. Several teachers have commented on how their perception of some of the students have shifted significantly for the better as they have observed the students take on leadership and organizational roles within their new communities. In another example, the ePortfolio system that was developed by one of the students served as a prototype for school-wide implementation, and is currently being tested in several classrooms.

Student expertise and needs

Due to the realignment of the social infrastructure of design, the design outcomes further reflected student expertise and needs, and expanded the understanding of what it means to learn through technology at the school site. As a result of this shift in design focus, the 12 students who joined the group for the second year each engaged in technology-mediated activities related to their personal interests. The design outcomes reflected student knowledge and needs. For example the e-sports community designers leveraged their deep knowledge of current gaming practices outside of school, in particular the rise of e-sports and the tournament formats for such events, to successfully host their own events, while the students developing the financial literacy website utilized their knowledge of their peers to identify a need for financial literacy education resources. These "boundary-crossing" (Akkerman & Bakker, 2011) technology practices were not available in the school environment prior to this proposed intervention.

Conclusion and implications

The findings from this study not only suggests that students should be critical partners in the design of technology-mediated educational practices, but that continued examination of *how* students engage in such partnerships can critically influence the design outcomes. The realignment of social infrastructures for design, and the consequent designs that emerged demonstrate that infrastructuring social relations of design can lead to the design of interventions that remediate traditional power relations in schools to produce more equitable technology practices that reflect student expertise and needs. In particular, student engagement with participatory design seems to lead to the kind of organizational learning characterized as 'boundary crossing' (Akkerman & Bakker, 2011), which views learning as the expansion of the object of activity systems through the hybridization of traditionally isolated activities within an institution. It is important to note that this study only highlighted some of the potential contributions students can make in technology design efforts, and deeper studies that examine the micro-interactions that mediate the kind of positive outcomes described here are needed to consistently produce positive outcomes. Furthermore, there needs to be a more comprehensive understanding of how knowledge embedded in semiotic tools created by students travel across the school ecology, and how they are taken up by other stakeholders. Moving forward, we hope to contribute to understandings in both of these directions.

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Assessing Student Generated Infographics for Scaffolding Learning With Multiple Representations

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Abstract: Student-generated multiple representations are increasingly used in science education, thereby creating a challenge for educators to assess these inscriptions. This paper used student-generated infographics created collaboratively in classrooms where secondary school students were engaged in authentic science news reporting and inductively generated tools for assessing quality infographics in authentic learning contexts. Results showed student-generated infographics can be assessed for dimensionality of the represented topic as well as for representation of understanding. Findings have implication for facilitating learning with infographics and analysis of visual research data.

Keywords: multiple representations, infographics, assessing student-generated artifacts

Lemke (1998) identifies two aspects of science literacy: understanding of concepts and the ability to use multiple representations scientists use to represent and explain a given phenomenon. Accordingly, the ability to use visual representations has become an emerging field of research and practice in science education (Gilbert, 2008). This notion of developing representational competence—the ability to understand, create and critique multiple representations (diSessa & Sherin, 2000) has moved towards using student-generated representations (Van Meter & Garner, 2005) that involves the use of learned representations such as quantitative charts as well as inventive and qualitative drawings.

One of the challenges in using student-generated representations such as infographics—visual representations of data and ideas—is assessing students' work and providing feedback because students often come up with inventive representations that may not have a benchmark. Lack of meaningful support could possibly lead to students' superficial understanding of the concept and failure to understand the relationship between represented phenomenon and the representation. In this paper, we used preliminary analysis of student-generated infographics collected as part of a bigger science literacy project to determine aspects of quality infographics. More specifically, we'll address the question "What are the aspects of quality infographics that teachers can use to assess student generated infographics"? Addressing such issue will help teachers to facilitate infographic-based learning and instruction and foster learners' representational competence.

Infographics as multiple representations

The use of multiple representations in learning and instruction has been a major area of educational research and practice for decades (Gilbert, 2008). Recent attention has moved towards student-generated representations as learning tools and outcomes. Researchers consider student-generated representations to be effective learning strategies similar to summarization and prior knowledge activation (Van Meter & Garner, 2005). An infographic (short for information graphic) is a form of representation of data and ideas often used to communicate with the general public rather than with scientific audience (Gebre & Polman, 2016). It combines the use of quantitative and qualitative data as well as qualitative cues to facilitate readers' understanding of the represented information.

Recent studies show that infographics are increasingly used as learning/instructional tools in secondary school context (Gebre & Polman, 2016; Polman & Gebre, 2015). Although infographics are sometimes referred to as data visualizations implying a visual representation of quantitative data, in the context of our project students often combine up to 4 or 5 types of representations in one infographic and work at multiple layers including the data level, visualization level and the holistic infographic level. By "layers" we mean levels or building blocks students work on in the construction process. The first is the *data* layer where students understand the nature of the data such as quantitative versus qualitative, categorical versus interval data or actual versus proportion data. While the nature of the data they collect depends on the nature and scope of the topic they are working on, students use multiple sources to triangulate their data and determine its credibility. They also organize the data in a way that is appropriate to what they intend to communicate. Polman & Gebre (2015) described how an experienced designer sorted the data when she was asked to create infographics for publication from already collected data.

Data visualization is the second layer. At this layer, students make choices related to determining what kind of visualization helps to meaningfully represent the kind of data they have. For example, pictures and drawings provide physical association with the represented object. Quantitative graphs, on the other hand, do not have physical association with the represented data; rather, they provide insight about the inherent structure of the data that a table cannot provide. Process related data is best represented using a flowchart or schematic diagrams. Semantic maps represent relationships between concepts. Decisions about the type of visualization depends on the nature of the data, the features of the visualization tool and students' understanding of the relationship between the two—data and representation. It is also possible that students can come up with invented or cultural representations which are not taught at school. Thus, this layer deals with appropriate visualization that in turn helps to develop visual thinking and problem solving (Azevedo, 2000; Reed, 2010).

The third layer is the *infographic layer* or the holistic layer. In this case, the infographic becomes a collection of visualizations representing various data and ideas as well as the organization, layout, and qualitative cues of the communication. When working at this layer, students deal with assembling a holistic argument, constructing explanations, organizing sources, and communicating their understanding based on scientific practices of data-driven inquiry (Kuhn, 2010). In addition to the data and organization, students also determine completeness of representation and contextualize it for possible readers.

Assessing student-generated infographics

Formative assessment of students' work and providing meaningful feedback for improvement is challenging in the context of infographic-based learning and instruction. This is so because students often choose different topics to work on thereby leading to the absence of a defined answer or way of doing the infographic. In concept maps, for example, it is possible to use expert-generated map as referent to assess student generated artifacts (Rye & Rubba, 2002). This is because a) often students in a class work on the same project topic in creating the concept map and b) it is relatively easier to create concept maps by experts in the field that can serve as a benchmark. Infographics are used as both learning and communication tools in the context of science literacy where students choose different topics that make sense to them or their community. One of the teachers in our project memorably said "it is easier for me to let students choose their own project topic and then support them in finding the data they need rather than choosing a common topic for all students and then working on their motivation". The challenge with this approach and infographic-based instruction is the absence of guideline for assessing student-generated artifacts. This is also a challenge in general areas of student-centered instruction especially when student-generated artifacts are in visual forms. In this paper we use 30 student-generated infographics and analyze them inductively to come up with aspects for quality infographics.

Project and methods

STEM Literacy through Infographics (SLI) is a design-based Development and Implementation project (DIP) funded by the US National Science Foundation (NSF). The project focuses on developing young adults' (grade 10 to 12) science literacy, mathematical reasoning and representational competence through actively engaging them in a collaborative process of creating data-driven infographics for authentic online publication on http://science-infographics.org. This DIP is a continuation of a two-year exploratory project and currently involves five traditional secondary schools, one alternative experimental secondary school, one after school program and one summer program in three states in the US—with a total of 1084 participating students. Data used in this paper was collected from two sites in a large metropolitan area in the Midwestern United States: a suburban public secondary school with socioeconomically and ethnically diverse population and an after school internship run at a mid-size private university. What students do in the project is described in detail elsewhere (Gebre & Polman, 2016). However, we briefly described it here to provide context. In face-to-face classroom context, students work in pairs or individually on a) identifying a science related topic to work on, b) searching for relevant data from online sources and databases (e.g., the Centers for Disease Control, National Institute of Health, Environmental Protection Agency, etc.), c) organizing the data and creating infographics, d) providing peer feedback using online collaborative tools (e.g., VoiceThread), e) getting feedback from an external editor who is the curator of the online publication website and member of the project (with PhD in Chemistry) and f) revising the infographics and submitting for publication. The data used for this paper are draft and final versions of 30 infographics produced by participating students in one of the six schools.

Data analysis involved openly comparing student-generated infographics and identifying the similarity and/or differences between them. The author used six infographics (that were not part of the 30 analyzed here) and compared them with the purpose of delineating features where infographics differ or align. He then developed a rubric with eight dimensions to determine quality of infographics. Two research assistants reviewed the dimensions at different times and provided comments for improvement based on their analysis of the infographics. Both students reported challenges of using the eighth dimension ("parsimony") as it became too subjective to assess. We then dropped "parsimony" and scored five more infographics using the rubric. This was followed by discussion of the scores. One of the research assistants and the author scored another six infographics and discussed their results. We then coded the draft and final versions of the remainder of the infographics.

Findings and discussion

Results showed student-generated infographics can be assessed in terms of seven features listed below

Types of representations. Infographics vary in terms of the various forms of representations they have (icons, bar charts, drawing, non-label text). Some infographics have just one visual representation while others have as many as five types.

Distribution of information. A related feature is whether information is distributed over different types of representations or are students repeating the data they presented in one form to another form. That is, the repetitive versus complementary nature of the data presented in various formats.

Dimensionality. Some infographics are rich in terms of content and others not so. Dimensionality relates to how many aspects of the represented topic are addressed in the infographic. It has to do with the depth, richness or completeness of the infographic to communicate the intended purpose or to tell a story.

Nature of data. In the context of our project, infographics are tools for students to make data driven arguments about the topic they are interested in. The question then becomes what kinds of data are students including in their representation (e.g., raw or proportional data, quantitative or qualitative data)

Contextualization. Most of the students pick project topics based on whether or not the topic is relevant to them or to someone they know—what we call "personal context" to the project. For example a student chose to work on "cauliflower ear" because he is a wrestler and has experienced the problem personally. The question is whether such context is communicated to readers through the infographics. Is there enough contextualization for readers to understand what the infographic tries to communicate or why it matters? Are readers able to answer "so what?"

Correspondence or alignment between various parts. This criterion includes both conceptual and technical alignment between various elements of the infographics. For example, does the title represent what is represented in the body of the infographics? Is the use of colors and shapes consistent through out the infographics?

Sources. Are there multiple, credible sources for the data and claims represented?

Each aspect discussed above was scored out of 3 points using the rubric. Our purpose was not to focus on the numeric value of the scoring, rather on the qualitative improvement of each infographic (and the representational skills of the learners) from the draft to the final version. We focused on the continuum nature of the scoring that range from 1 to 3 to represent low, medium and high quality work, respectively.

Figure 1 presents the average score for draft and final versions of the 30 infographics. The highest scores are for "distribution of information" and "sources" both in the draft and final versions, implying a) students do not use repetitive representations or they use different kinds of tools to represent different aspects of their topic/data, and b) they provide multiple credible sources for the information they include in their infographic. Figure 1 also shows that complexity of representation (dimensionality), which has to do with "completeness" of the representation, has the least score both in the draft and final versions. Based on our classroom observation, this happens because students sometimes perceive infographics as creating one quantitative chart as opposed to making a complete argument or story.

The use of multiple representations is the hallmark of scientific reasoning and explanation (Lemke, 1998; Gilbert, 2008; Yore and Hand, 2010). Our findings build on diSessa's (2002) work on representational adequacy of student-generated representations and the Polman & Gebre's (2015) work on framing infographics as scientific inscriptions. It also extends prior work by inductively generating features of quality infographics. We'll build on this preliminary analysis to help educators and students who use infographic-based learning instruction in their classes. From a research perspective, our existing and future analysis contributes to understanding cognitive aspects of infographic-based arguments and visual methods in research data analysis.

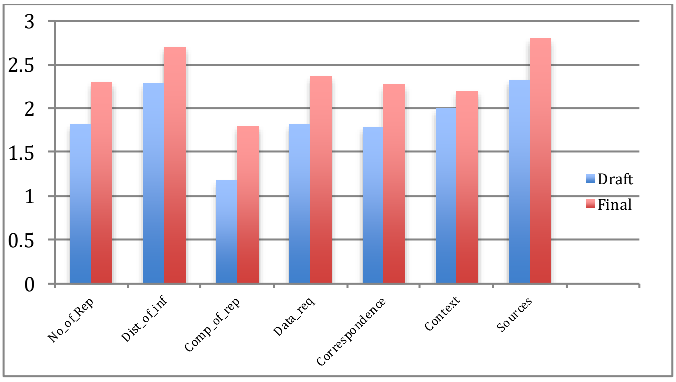

Figure 1. Average scores of draft and final version infographics (N=30).

The use of multiple representations and semiotic tools is necessitated by the demands of the science curriculum (Lemke, 1998; Yore & Hand, 2010). Infographic serves as a learning tool and uses multiple forms of representational tools. Accordingly, assessment of student-generated infographics needs to address both the content and the representation aspects of learning. This study helps teachers who design learning with infographics to consider these two main aspects while assessing students' work.

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Role of Socio-Emotional Interactions on Mutual Trust and Shared Mental Models in a Case Study of Programming Teams

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Abstract: This exploratory study examines international physics teams that competed in a two-day challenging hackathon (computer programming competition). Through case study analysis of three representative teams, we examined team interactions in terms of socio-emotional interactions, trust and shared mental models (SMMs). High and low performing teams were identified based on number of social challenges experienced by the team. Challenges and goals were measured using a modified version of AIRE (Järvenoja, Volet, & Järvelä, 2013). Using a mixed methods exploratory approach, preliminary results showed that teams whose members (a) interacted with more positive social-emotional interactions (b) reported more team-oriented goals, and (c) had prior familiarity with each other, reached higher levels of mutual trust and shared mental models. Specifically, findings highlight the role of socio-emotional interactions in enhancing mutual trust and shared mental models, and have implications for teams composed of learners with heterogeneous expertise in CSCL environments.

Objectives and significance

Physics teams were examined in the context of a challenging computer-supported hackathon. A hackathon is defined as a programming competition where several programming teams compete to program an innovative idea (i.e., a physics phenomenon in this study) within a specific timeline. Although emerging rapidly into the educational domain, such a CSCL context is less studied both empirically and theoretically. In the context of this study, teams were examined to see types of challenges they faced during their interactions, and whether positive socio-emotional interactions helped them overcome the challenges, build mutual trust and regain strong bonds of shared mental models between members.

Theoretical framework

Collaborative team-based learning situations are powerful learning experiences, but may face potential challenges, such as different levels of expertise, engagement and commitment (Järvenoja et al., 2013), especially if they are from heterogeneous backgrounds. Previous literature has shown that such challenges can hamper (a) mutual trust, and (b) shared mental models (SMMs) between team members, two mechanisms that are significant for team effectiveness (Salas, Burke & Sims, 2005). Mutual trust is defined as the "shared belief that team members will perform their tasks and protect the interests of other team members" (Salas et al., 2005, p. 561), and SMMs refer to "knowledge structures held commonly by members of a team that enable them to form accurate explanations and expectations for the task, and in turn coordinate their actions and adapt their behavior to the demands of the task and other team members" (Cannon-Bowers et al., 1993, p. 228).

Dealing with the possible challenges that emerge in team tasks requires applying effective interpersonal skills. Previous research has found co-regulation, metacognition and socio-emotional interactions as factors of effective collaboration (Lajoie et al., 2015). For the purpose of this paper we examine socio-emotional interactions experienced in teams with the goal of identifying whether positive interactions lead to fewer challenges, more trust and higher SMM bonds in this complex, competitive, and time-limited social learning context (i.e., hackathon). Our premise is that positive socio-emotional interactions can mitigate challenging team moments and help maintain high levels of SMMs and mutual trust between team members. Furthermore, teams who possess individuals with more team-oriented goals than individual-based goals create a stronger team atmosphere and work collaboratively with a higher sense of unity. Thus, based on these factors we hypothesize that teams with more positive socio-emotional strategies and team-oriented goals will have less team challenges (or deal with challenges more effectively), high levels of mutual trust and stronger SMMs between team members, hence leading to enhanced team effectiveness.

Methods

Participants

17 international teams of 2, 3, 4, or 5 participants (N= 48 students; Average age= 22 years; 73% male) invited from around the globe participated in a two-day Physics Programming competition held in a North American University. Students ranged in expertise from Software Engineering to Math and Physics, and teams were composed of members with varied levels of programming expertise. Teams were formed based on students' individual interests and were then asked to collaboratively build a novel computer program that could demonstrate a physics phenomenon of their choice artistically. Teams were audio and video recorded at different time points during the competition (i.e., beginning, midpoint, and before submitting their projects). Individuals were asked to report general demographic information and fill in several questionnaires based on the AIRE instrument (Järvenoja, Volet, & Järvelä, 2013), an instrument designed to capture the nature of socio-emotional regulation processes that students employ during collaborative learning. AIRE was used to capture students' goals for participating in the hackathon (administered at beginning of competition), as well as the challenges they reported (administered at the end of the competition). Teams were judged and ranked by a group of expert judges at the end of the competition, and winners were awarded valuable prizes.

Design

A case study analysis of three representative teams was conducted using a mixed methods approach to analyze factors of team effectiveness during the physics competition. These teams represented teams who: (a) ranked high (in terms of team productivity), reported low levels of challenges (representative team labelled *Team A*), (b) ranked high, reported high levels of challenges (representative team labelled *Team A*), and, (c) ranked low, reported high level of challenges (representative team labelled *Team C*). Each of these teams were composed of three multicultural international members.

Data analysis

Audio and video data were transcribed verbatim. Two raters segmented, and coded the transcriptions based on socio-emotional interaction codes (derived from Garrisson, Andeson & Archer, 2001) including affective, intearctive and cohesive social presence (see Table 1 for some examples) to identify levels of socio-emotional interaction competency in students' teamwork. Pearson's percentage of agreement was calculated as 74%. Apart from demographic data, answers to the goal questionanire derived from the AIRE instrument, Trust questionnaire (Costa & Anderson, 2011) and SMMs questionnaire (Johnson et al., 2007) were also analyzed quantitatively.

Table 1: Examples of socio-emotional codes (refer to Lajoie et al., 2015 for the complete codebook)

Valence	Social Presence	Subcategories	Descriptions
Positive Socio-Emotional Interactions [P]	1. Affective Social Presence	1.1. Use of humor	Explaining in funny sentences to provide laughter
		1.2. Mutual Respect	Showing respect or polite disagreement
		1.3. Interpersonal sensitivity	Showing caring and understanding
	2. Interactive Social Presence	2.1. Continuing a thread	Adding to someone else's discussion
		2.2. Expressing appreciation, encouraging contributions	Attempting to encourage the sustained involvement and contributions of other group members.
	3. Cohesive Social Presence	3.1. Using inclusive pronouns	Addressing or referring to the group using plural pronouns; e.g. we, our, us.
		3.2. Phatic, Salutations	Greetings / general utterances in social interactions
Negative Socio-Emotional Interactions [N]	Internal	1. Negative criticism	Undermining a group members' task by negatively criticizing their work
		2. Discouraging others' participation	Not assigning tasks to someone, ignoring one's participation
		3. Passive listening	Not listening actively, showing distractive behaviors.
	External	4. Task difficulty (technological issues)	Task difficulty posing stress on the team.

Results

Although teams were ranked on their programming outcomes rather than their collaboration skills, we found effective collaboration was associated with fewer team-based challenges. Thus we refer to an effective team as a team with less team-based challenges. Based on the AIRE instrument, low number of challenges were encountered in Team A but high frequency of challenges in team B and C. Table 2 demonstrates team differences in terms of challenges encountered.

Table 2: Heat map of challenges reported by students in each team (derived from the AIRE instrument). Darker cells indicate more occurrences of challenges

	Team 1 participants			Team 2 participants				Team 3 participants			
1. Our goals for the competition were different.	1	1	0	0	3	2	3	4	4	2	3
2. We had different priorities.	2	0	0	0	3	2	3	4	3	3	3
3. We seemed to have incompatible styles of working.	1	0	1	1	2	1	2	4	3	3	2
4. We seemed to have different styles of interacting.	1	0	0	0	1	1	3	2	2	1	2
5. People in our team did not connect very well with one another.	0	0	0	0	1	2	2	2	2	2	1
6. People had very different standards of work.	2	1	1	1	1	3	0	2	3	3	2
7. Team members were not equal.	0	0	0	1	3	1	2	0	4	4	1
8. Some people were easily distracted.	2	2	0	1	2	2	2	3	4	0	2
9. Our ideas about what we should do were not the same.	3	1	0	0	2	3	3	4	4	4	2
10. We differed in our understanding of the concepts/task.	2	1	1	0	2	1	2	4	4	4	2

The transcripts and AIRE data indicate differences in effective collaboration. Team A and B showed high positive and low negative socio-emotional interactions, whereas Team C showed low positive and high negative socio-emotional interactions. An analysis of the AIRE goal statements demonstrated that team-oriented goals were more prevalent for team A and B than C. Excerpts of socio-emotional interactions, and examples of goals for each team are presented in Table 3. One antecedent to Team A's productive collaboration is that they had past experience working together which increased the speed at which trust was established. High levels of trust enabled them to direct their attention rapidly towards the main task from the beginning hours of the competition.

Table 3: Excerpts indicating coded positive/negative socio-emotional interactions within team interactions

Examples of Reported goals	Prior Familiarity	Excerpts demonstrating social –emotional interactions	Ranking
Not let my team down (team-based) Win first place (team-based)	Team members knew each other from before	But the radius of the circle is exactly this [N3] -Oh yeah you're right [P2], my apologies [P1], Okay now I understand your equation [P2] -Does it work? [P2] -See when I click on it, it tells me which bracket [P2] -Yess! [P2] And if you click outside? [P2] -You are a true king! [P1] -it's beautiful! Hahaa!! [P1][P2]	Team A (Winner) **High** positive socio-emotional interactions
Not let my team down (team-based) Learn as much as possible (individual-based)	No prior familiarity	- Our angular momentum is still off a bit. [P2] - It has to be to the power of 12, yeah? [P2] - Well, our eccentricity should be 0.05 [P2] - What's that range in the bottom? [P2] - Hold on a second, I'm just going to do this [P2] - Our eccentricity, there you go! [P2] - I just solved the memory leak! [P2]	Team B (Winner) **High** positive socio-emotional interactions
Make sure all members contribute equally (individual-based) Have a good time and enjoy the experience (individual-based)	No prior familiarity	-Why didn't we do that earlier? [P2] -No, you don't understand [N3] we have that! [P2] -Okay where do we insert it? [P2] -Oh my goodness! [N3] it's in the description!! [N1] Girl continues to text in Facebook without involving herself much in the project. [N4][N2]	Team C (Loser) **Low** positive socio-emotional interactions

Teams A and B who demonstrated high positive socio-emotional interactions, had more strong levels of trust and SMMs, whereas team C who had lower levels of positive socio-emotional interactions revealed weaker trust and less strong SMM bonds (refer to Tables 4 and 5 respectively).

Table 4: Sample items for measuring trust in team members (dark cells indicate high levels of distrust)

Item	Team a			Team b			Team c		
9. We do as we have promised	7	6	7	6	5	7	3	5	7
10. Some of us have often tried to get out of previous commitments	1	1	3	2	2	6	7	6	7
11. We try to address each other`s interests as much as possible	6	6	6	6	5	7	7	5	4
12. We work in a climate of cooperation	7	7	7	6	4	6	7	7	4
13. We discuss with issues and problems openly	7	7	7	7	4	6	7	6	4
14. While taking a decision, we take each other`s opinions into conside	7	7	7	6	3	7	7	6	5
15. Some of us have tried to hold back relevant information	1	1	1	1	2	5	4	6	4
16. We have minimized what we tell each other about our personal life	3	2	5	1	1	5	7	6	7

Table 5: Sample items for SMMs between team members (dark cells indicate low levels of SMMs)

7. My team discusses its goal and attains the agreement of teammates
8. My team knows specific strategies for completing their various tasks
9. My team knows the general process involved in conducting a given task
10. My team understands that they have the skills necessary for doing various tasks
11. My team communicates effectively with other teammates while performing tasks
12. My team supports personal and team-level skill improvement
13. My team defines its communication style at the beginning of their work

Team a			Team b			Team c		
5	4	5	5	4	5	5	5	2
5	5	5	4	4	5	5	4	3
4	4	5	4	4	4	5	5	5
4	4	5	5	4	5	5	2	3
4	4	5	3	3	5	1	5	4
5	5	5	4	3	4	5	4	3
5	5	5	5	4	5	5	5	3
3	3	5	3	4	5	5	4	3
4	4	5	4	3	5	2	5	3

Conclusions and implications

As guided by the literature, results of this study revealed that effective team collaboration is based on building positive socio-emotional interactions and also team-oriented goals. Results also showed that prior familiarity with members can lead to higher trust levels. We contend that these factors should be examined simultaneously rather than in isolation; i.e., focusing on only one factor is not sufficient for guaranteeing high or low team effectiveness. However, the relative influence of each of the three afore-mentioned factors should be considered. Our preliminary findings suggest that the role of positive socio-emotional interactions was more significant than the other two factors (team-oriented goals and prior familiarity) in determining team effectiveness. For example, winning team B faced high challenges and had no prior familiarity with each other, but demonstrated high positive socio-emotional interactions, high trust levels and strong SMM bonds. Although effective in describing the three teams and how challenges were mitigated by positive socio-emotional interactions, these findings are not yet generalizable. In a larger examination of all of the teams, we aim to further explore the validity of this and examine the relative power of positive socio-emotional interactions in determining team effectiveness. This study has implications for heterogeneous CSCL teams with different levels of expertise, communication methods or commitment levels; in that such teams need to raise their awareness of the relative power of socio-emotional interactions, and how their interactions can significantly influence the team climate, in a positive or negative direction. Teams can also benefit from seeing whether each member values the task at hand, so that student members can work closely based on their shared goals. Furthermore, ice-breakers can be used to increase familiarity of members who have not worked together prior to the team event and facilitate building trust bonds between each other.

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Fostering a Knowledge Building Community in a Primary Social Studies Class to Develop Humanistic View on Real World Problem

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Abstract: This study examined the nature of reasoning of 30 primary five students working on a social studies topic on 'Appreciating the World and Region We Live In', contextualized to a local community, Kampong Buangkok. Results showed that students not only became increasingly motivated in the processes of theorizing and collective solutioning, they were also developing a higher level of consideration for the people and their activities, among spatial and temporal considerations. We found clear evidence that students' subject-based literacy skills improved significantly over the course of the KB lessons.

Introduction

Much educational research is motivated by the need to build students' competencies in the face of the rapidly changing world and its demand. What qualifies our students to fluently navigate and make sound decisions in this complex world? A series of lectures designed for Harvard graduates dealing with moral dilemma heightened the need to look into the affective domain of learning including developing humanistic perspective to approaching problems (Krathwohl et. al.). The aim of this study is to detail enactment of knowledge building (KB) pedagogy and technology in a primary five class working on the topic of preservation of "Kampong Buangkok" in Singapore and investigate the impact of such an approach on developing 21st century competencies, including a humanistic perspective in their decision-making process.

Background

In the past decades, educational research and learning sciences have motivated educators to shift their practice. Many changes in educational context have indeed happened. Plainly using the 'inquiry' method and thinking skills in the teaching of history is an archaic approach dating decades back to the 1950s and 1960s (Woodhouse & Fleming, 1976). Around the world, especially during transition phases, history teaching plays a formative role in empowering students to "become good citizens of their own nations, of troubled continents and of our endangered global village" (Harkness, 1994). In Singapore, we are in the transition from our founding 50 years of nationhood to the next 50. According to PM Lee (2015), we must preserve what has worked for us: multiracialism and interdependence, and strive for what will forge a stronger 50 years for Singapore: identity and community. The concepts that PM Lee mentions as crucial for Singaporeans requires much more than just an intellectual exercise to deconstruct them in class: it requires a direction from a "values agenda" approach that empowers students to refine these values in contextualized and relatable ways that history lessons can provide (Kelsey, 2009).

KB presents a model of student-centered collaborative inquiry. KB teachers are encouraged to actively engage students in thinking through the diverse but related ideas that emerge in the class inquiry and supporting them in ways to revise and improve these ideas into more formalized explanation or proposal ("theory"). This idea-centric approach never fails to surface students' thoughts and perspectives that surprised teachers. This is a piece of clear evidence against the misnomer that some teachers have about their students; t their students cannot think. In fact, all students, regardless of age and ability, have ideas. KB introduces students to a culture in which they see new responsibilities in themselves as learners, contributing and negotiating to develop new insights about their inquiry (Paavola & Hakkarainen, 2005). More importantly, students understand that they need to function as a network to discuss and exchange ideas with their peers (Lee, Chan, & van Aalst, 2006; Scardamalia & Bereiter, 2003; Bereiter, 2002).

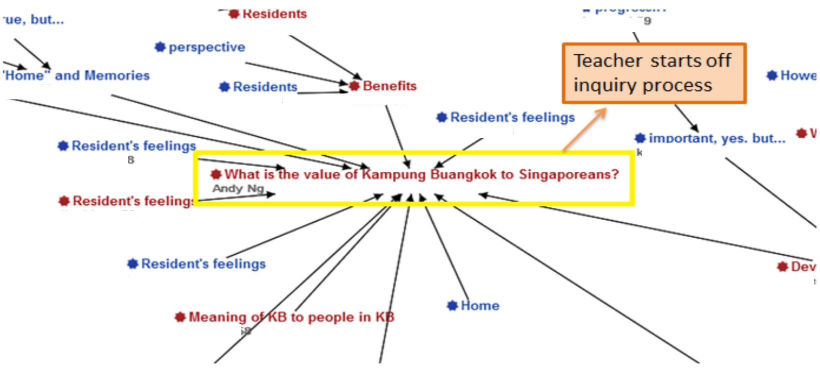
Design of study: Knowledge Building in Social Studies classrooms

In a series of studies on KB pedagogy in Social Studies in local schools, it was found that young children were able to engage in online collaborative sense-making and they were also found to have developed skills in asking deeper questions and tackling deeper concepts (Tan et al., 2014). However, it was also found that teachers struggled to cope with KB pedagogy. They found it difficult to respond to students' ideas and to keep up with students' development of ideas (Chai et al, 2012). As such, more studies on KB classroom needs to be done to address teachers' anxiety and competencies.

Teacher's lesson design

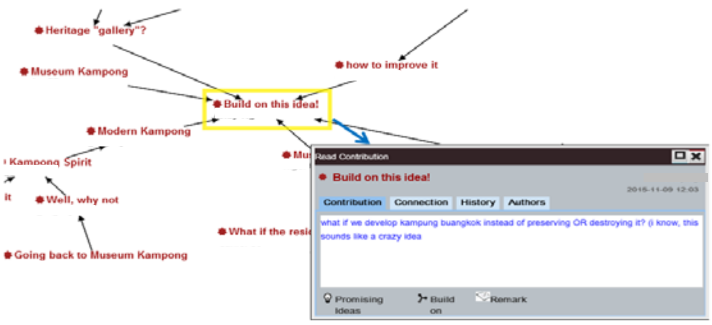
The study was done over two weeks in a social studies class of 30 primary five students (age eleven). The theme that students were working on was 'Appreciating the World and Region We Live In.' The teacher contextualized the inquiry to a local community, Kampong Buangkok. Students were first taken on a field trip to Kampong Buangkok to collect data for their case through observations and interviews.There were four phases (adopted from A-C-T-S, the school's overarching pedagogical tool) to organize these KB lessons:

<u>Phase 1: Asking questions</u>: The lesson began with an overarching question "What is the value of Kampong Buangkok to Singaporeans?" (Refer to Figure 1), initiated by the teacher on an online electronic discourse platform, (KF). KF platform provided an open discourse space for students to explore their interpretation and biases of the problem. The big idea that the teacher wanted students to focus on was to navigate the tension between progress and heritage. This unit is an enrichment unit to the theme of "whether civilization is a blessing or curse to Mankind". A set of KB scaffolds (e.g. <I can build on this value by> ; <I need to understand>, <Iwere put in place to guide students through their ideas.



<u>Figure 1</u>. Teacher posted the initial question on KF

<u>Phase 2: Challenging ideas</u>: Following the first lesson, the teacher highlighted a student's questions posted on KF: 'Are the people or the economy more important?' and facilitated a whole-class discussion to challenge students' current thoughts. He led students through a discussion to talk about the two main camps of thoughts emerging on KF at that moment, i.e. one camp supported the "People" while the other supported "Economy". A student suggested 'What if we develop kampung Buangkok while preserving it and not destroying it either?', the class picked up on that and the teacher posted that promising idea onto a new KF view. (Refer to Figure 3). The teacher continued to emphasize on consensus, reminding students to consider multiple perspectives rather than winning an argument.



<u>Figure 2</u>. Promising idea identified in class to shape the inquiry further.

Phase 3. Think Further. Following the question 'What if we develop Kampung Buangkok while preserving it and not destroying it either?', three promising ideas were put up on KF for further pursuit. The class agreed on a set of selection criteria based on the level of amalgamation of promising student-proposed theories for what the "town council" could do instead of a one-sided approach. The selected promising theories includes "developing a museum in Kampong Buangkok to attract tourists"; "turning Kampong Buangkok into a flower gallery like Botanic Gardens"; "developing half of Kampong Buangkok into a modernized residential area while leaving the other half alone". Students were to have a final read-through and discussion on KF about what ideas among the three that they would propose to the "town council". They would then have a conclusive verbal discussion before bringing their ideas up to the "town council".

Phase 4. Reflect Forward:
The teacher posed six questions in a new KF view for the students to reflect on their experience. Questions included: 'In the first place, why is there even a debate as to whether Kampung Buangkok should be preserved or developed?' and 'If there are future opportunities for me to participate in projects aimed at protecting places of heritage, would I be interested, even if it would take up a lot of my time and effort? Why or why not?'.

Throughout the lessons, the teacher would talk about KB principles (e.g., improvable ideas, collective cognitive responsibility). The teacher would say things like "Spend the last 15 minutes of the lesson reading through all the notes contributed to KF, and process all that information" thus cultivating the habits of collaboration in the class.

Results

The data collected comprises of students' notes on KF, classroom observations, students' and teacher's reflection notes. We analyzed the data for three components: (i) students' motivation in solving the problem; and students' primary considerations in response to the problem and students' emotional connection to the problem. 13 out of 15 students responded positively when asked about their interest in the inquiry. Some attributed the source of their interest to their learning experience which influenced their developing interest in social studies,

> *"If I had the opportunity, I would participate. I believe that I will be able to gain more knowledge on my surroundings and further understand the value of heritage sites and what they provide the society with."*

More importantly, the students were seen to grow to really care about the problems and issues that arose in the course of the KB discourse.

> *"I realised (or so I though) that REAL town council officers would come and the residents of KB really depended on this. Nevertheless, even after I knew they were fake I still treasured the experience and the project."*

We also observed students perception of the issue at hand grew from merely tackling the design and utility of space in Kampong Buangkok (Spatial) to that of taking the lens of the residents of Kampong Buangkok (Social). This Social dimension included students' attempt to understand the behaviour and activities of people in Kampong Buangkok (Social), to considering specific events or organization (Temporal) (Table 1). Though all three types of considerations increased, the most significant increase was the social perspective (Fig.1, from 6.7% to 21.4%).

Table 1: Three main categories of considerations revealed in students' posts

Codes	Descriptions	Examples
Considering from a social perspective	Considering human needs, behaviour, and their social activities.	"Kampung Buangkok is valuable to - the residents there. They might feel very akward in another housing estate without the hustle and bustle of the kampong."
Considering from a spatial perspective	Considering utility of space, including location and scale.	"KB can be made into shopping centres and sports facilities as there are not many near that area."
Considering from a temporal perspective	Considering organization of time and significant event	Will we still have this Kampong 20 years from now? 50 years? Our "heritage homes" are important, but people whom they benefit are the extreme minority"

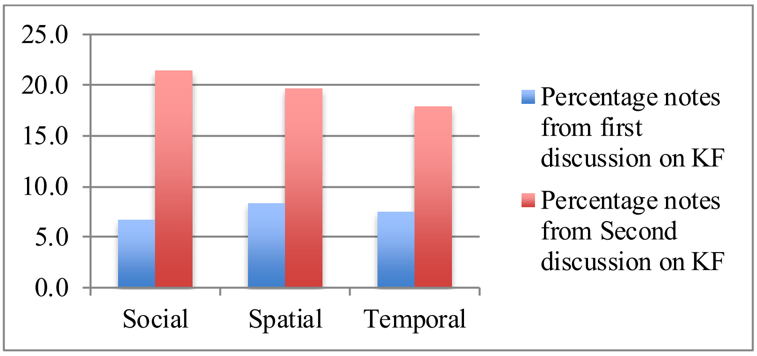


Figure. 3. Percentage of students' notes that revealed different sets of consideration.

We noted anaffective dimension emerging in students' notes. The tone and vocabulary used by the students showed their concern about their ideas and proposals. We were detecting notes that revealed analysis of the problem through description of feeling (e.g. "*if they wanted to trespass and direspect the residents, they could, couldn't they?")*, notes containing emotional expression *(e.g. "don't you think that residents will feel cooped up in KB with buildings around?")* and even notes with moralising tone *(e.g."This value is important, but - progress from destroying people's homes?"*).

The 'aha' moment in these lessons was the teachers' account of his students asking him what would happen after they presented their plans to the "town council". They wanted to know if it would make any difference to the real Kampong Buangkok. And if it couldn't, they asked the teacher if they could speak to someone genuine (like a real town council) who would do something about the real problem.

Conclusion and Discussion

The evidently positive results showed in this group of high achievers regarding their motivation in tackling social issues and especially with their increased focus and connection with the social aspects of the problem within such a short implementation cycle surprised both the researchers and the teachers. An anecdotal but important observation from the teacher was that he noticed his class becoming less competitive in this KB journey. Competitiveness is a common trait in these high-achievers in previous years. Though we also managed to see a corresponding improvement in the quality of students' explanation, that was not the most critical to the teachers. Teachers saw that the students were pursuing real-life problem beyond just an academic pursue when they fostered KB culture in class. Itwas sufficient to convince them in sustaining such practice in their class.

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Exercising the Heart of History Education: Negotiating the Past Through a Principle-Based, Technological Driven Knowledge Building Culture

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Abstract: This study examined the use of historical concept in a class of Secondary one students inquiring on the topics on "Pre-1819 Singapore" and the "British Heritage in Singapore History" using a Knowledge Building approach and Knowledge Forum technology. Analysis of a selected groups of students 'contributions was done according to four level of negotiation revealed in the class' discourse. Students engaged in such historical discourse suggests the development of concept and process skill which points to the fact that knowledge building pedagogy and technology are conducive to quality teaching and learning of history. Results also pinpoint common misnomer about knowledge building in history class and how a teacher can facilitate such discourse.

Introduction

Learning History is often perceived to involve mainly memorizing of historical facts. To do well in History means to cramp those facts from the textbook into memory and then to be able to regurgitate the facts at an examination. This notion translates into a persistent pedagogical problem in history classes that emphasized on conventional narratives as the "dominant educational tool" (Resendes & Chuy, 2012). The Recent educational shift towards cognitive and social processes served to remind educators about the need to look into the nature of the subject as well as to how students think and learn about complex concepts. The introduction of historical thinking in History classroom, liken to the way a historian work to construct a historical explanation, is slowly influencing the way people understand about history lessons. In recent years, history teachers realize that they can no longer be the only knowledge dispensers in class because of how quickly their students could search for similar, if not more, of the required facts on the Internet. They are sensing a shift in their role to engage students in historical reasoning and inquiry on complex historical issues (Fulbrook, 2002).

Also, Learning Sciences Research (Bransford, 2002; Sawyer, 2008) has provided sufficient evidence to convince educators that students should engage in collaborative knowledge building activities which include questioning, researching, evaluating, analyzing, negotiating, and synthesizing to prepare for real knowledge work. This study attempts to study (i) the way in which students negotiate a historical phenomenon and recorded the pattern of interactions designed by the teacher in his Knowledge Building history class.

The classroom and teacher's design

The participants of this study were from one secondary one (grade 7) class. This class is considered the less academically inclined group in school. Humanities subjects for lower Secondary in the school ran on a modular system which means students only have three months (July to September) of a history lesson in a year while the rest are for Geography lessons. The teacher observed that the class tends to ignore contesting views or change to adopt the new view when they are made to do whole-class discussion during the introductory sessions

KB principles, activities, and teachers' rationale.

Table 1. Mapping the KB principles, the KB activities and the teachers' rationales behind the design.

KB principles	*Democratizing Knowledge; Improvable Ideas; Community Knowledge*		*Improvable Ideas; Real Ideas and Authentic Problem; Epistemic Agency; Constructive use of Authoritative Sources*		*Epistemic agency; Rise above; Knowledge building discourse*
Inquiry process defined in Syllabus	*Sparking Curiosity*		*Gathering Evidence and Exercising Reasoning*		*Reflective Thinking*
Teacher's pedagogical move	Start: Design for students to surface current/ intuitive understanding to the issue or theme	Seek: Design for students to formulate ideas/ questions relating to the issue or theme.	Spark: Design for students to read, exchange and craft online comments.	Stretch: Design for students to synthesize ideas based on peers' suggestions and craft "a better theory" note.	Scale: Design for students to reflect on their ways of learning and/ways of thinking
KB Activities designed by the teacher **(Stage 1: Pre-1819 Singapore)**	Teacher facilitates whole class discussion through a class mind-map recording students' initial idea of Pre-1819 Singapore	Students post initial questions about pre-1819 Singapore. Next, there will be a whole-class discussion in deciding the overarching inquiry question.	Students, in pair, craft their initial stand to the overarching inquiry question then they read and comment on their peers' notes (using KF scaffolds). The comments can be a disagreement, suggestions or areas of concern.	Students, in pair, review peers' comments. They then make reference to these comments and synthesize information to formulate a "better theory" (KF scaffold) to the overarching inquiry question.	Students reflect on how they derive at the enhanced theory (KF notes). They weigh which is the best enhanced theory. Teacher show students' historical growth through the KF analytical tools and observations.
KB activities designed by the teacher **(Stage 2: British Heritage in Singapore)**	Students share ideas and examples of "British Heritage in Singapore". They read the build-ons to their ideas (agree/ disagree with justification).	Students work in groups to synthesize ideas on heritage before formulating a group inquiry question that they want to explore further.	Students brainstorm and research on their group inquiry question and craft their initial stand. They then build-on to their peers' entries in the following areas: (i) relevance of their examples and research, (ii) quality of their research and/or (iii) suggestions of other examples.	Students, in groups, make reference, review and synthesize the information to formulate a final group inquiry question. They also consider comments to their new inquiry question	Students reflect on the following through a survey on: (i) their perception of history (ii) their ideas/ viewpoints of a collaborative classroom culture (iii) their opinions about KB and KF and its use in facilitating their historical thought processes.
Rationales for KB activities	Increases students' ownership and engagement of learning. Understands students' prior knowledge and/or misconception related to the historical issue. Brings about a culture of "democratization of Knowledge" and collaboration.		Enculturates meta-cognition for history Gets students to appreciate conflicting opinions. Brings about a "building-on" versus "answering" culture	Strengthens students' meta-cognition through iterations of evaluation and reconciliation of varied opinions, perspectives and/or ideas to the issue. Creates authentic history learning environment that emphasises on co-learning and referencing	Encourages reflective thinking with regards to personal learning process and development. Celebrates the growth of historical understanding and personal attributes of the students
Rationales for small group and whole-class activities	Allows students to appreciate diverse ideas from a community and for them to understand the need to "pull-together" diverse ideas to develop improved ideas.		Supports assessment as learning through the culture of cross-referencing. Helps students appreciate that history is a social construct and historical discourse involves negotiation and collaboration.		Develops students' understanding that good history research requires collective questioning and inquiry.
Affordance and Rationale(s) of Knowledge Forum	Provide a collaborative space for students to see the reservoir of ideas (e.g. questions, viewpoints and concerns) at a glance and increases possibility of students seeing connections between varied information/ideas. Support students' historical and meta-cognitive reasoning through its six KB scaffolds. Referencing tool facilitates the habits of incorporating others' ideas to refine one's own idea.				KF analytics tool provide timely analysis that allows students to reflect on their interactions and growth.

Analysis of Stage 1 inquiry: Pre-1819 Singapore

Data collected includes students' notes and learning artefacts, teachers' design document and reflection. In this case, we focused on students' notes to analyse for how and to which degree the students negotiate ideas on the historical significance of Pre-1819 Singapore and the historical phenomenon of British heritage in Singapore. We traced and analysed each group's theory development, their reflection on their reasoning process, using the 4 level of students' stance in KB discourse in History (Table 2).

Table 2: 4 level of students' stance in KB Discourse in History

Level	Students' stance from kb discourse	Descriptions
Level 1	Ignore opposing ideas in KB discourse	Cancellation of challenging or contesting comments (be it differing stands or areas of concerns) without explanation or justification
Level 2	Switch to take up opposing ideas without explanation	Conformity to the opposing stand of the contesting comments and disregard their initial stand without explanation or justification
Level 3	Summarize information from different viewpoints/KF entries	Content Combination by merging and matching ideas due to their similarity or relevance. No clear evidence of historical concept as the overarching frame of thinking
Level 4	Synthesize to formulate new understanding of the varied viewpoints, ideas and suggestions	Conceptual Combination by forming an 'theory' or 'question' that uses the discipline of history such as procedural concepts (i.e. causation, change and continuity) or substantive concepts* (i.e. power, political, economic) as the overarching frame of thinking

We trace a series of students' build-on notes on the inquiry question: "Why must we study pre-1819 Singapore?"

Pair A's first KF entry provided a reason for the importance of studying pre-1819 Singapore.

> *My (Our) Theory: "We need to know Singapore before 1819 because we can know about Singapore past… By doing this we can better understand Singapore recent excavation of Fort Canning (that) provide evidence that Singapore was a port of some importance in (the) 14th century and used for transaction between (the) Malays and Chinese. We can also know what places in Singapore has changed and what significant event that took place in Singapore, we can also know that if Singapore is in connection with the countries."*

Pair B neither agree or disagree with A. They posed a question to suggest a different perspective that Pair A could consider to better understand the question.

> *"My theory – we are convinced by them, We agree that it is important to know more about the history before the year 1819…"I need to understand – can you do research and tell us more about Singapore importance in the 14th century itself ""This theory cannot explain – how does knowing the recent excavation help us understand better of Singapore".*

They seemed to suggest that the importance of knowing pre-1819 Singapore should not be measured solely on how it has led Singapore to who we are today or the lessons that we could learn. Instead, every period of time is important for its' own existence (historical context). In short, Pair B was seen to be adopting a meta-view of studying history for its own sake and not history for something (*level 4 stance in KB discourse*).

With this build-on from their friends in mind, Pair A went ahead to read others' notes and using KF referencing tool, Pair A referred to a note with detailed elaboration on two points, first being that 14th century Singapore, and second point that emphasized on the need to study the different time period for its own purposes. Pair A then connected these ideas in their "better theory".

Analysis of Pair A's "better theory" showed an elaborated description of the 14th century (*level 3 stance of KB discourse*). It included phrases that stressed on time, which happened to be an important Historical contextualization. Example of the phrases include "*so that we will know what exactly happened then*", "*at that point of time*", "*back at that time Singapore is not…*" Also, Pair A's note also constrasted events included in peers' entries to highlight Singapore's importance in the 14th century, e.g. "*Singapore fell after 14th century because of better port in Melaka".*

Finally, they reflected on "how do they come to this better theory" and "why do they choose this way", Pair A echoed on how the idea of "that time" in their reading of other pairs' notes made them realise that "time" is an important element in historical explanation (*conceptual combination, level 4*). Pair A also expressed that they could not ignore the word "better" in the KF scaffold *A Better Theory* and therefore was constantly thinking of ways to make all information "glued together".

In summary, Pair A was observed to be reading and referencing to their friends' ideas in their notes. It was in this context of co-learning that explained how Pair A was able to synthesize different pieces of information and to use historical contextualization of time and causation to generate a better explanation for the inquiry question. In a similar vein, analysis generated from the KF analytic tool showed a higher frequency and longer span of conceptual words (e.g. relate, impact) as compared to content words (e.g. heritage, British) in the database.

Analysis Stage 2: British Heritage in Singapore

After experiencing an inquiry cycle showing how students were able to collaboratively construct new understanding, The teacher focused the second stage on bringing them through iteration of synthesizing and improving ideas. Students started at the initial stage of questions generation, then moving on to negotiation process and finally towards building a consensus that was demonstrated in their final product. Group A's KB entry it has been observed to change from "Is the British regulations good for Singapore?" to "Are we biased that we follow some British Education system until now?" through the knowledge building process. Students were more fluent in using KB scaffolds to ideate, e.g. (i) <I need to understand> the earlier question as too broad with no exact time reference and category and (ii) <New Information>a history-related question is about change.

A collaborative culture was developing as the teacher observed that Group A were able to enhance their final inquiry question using the idea of change and continuity, e.g. "*during our time with Malaya versus our time now"* (*level 4, conceptual combination*). This conceptual consideration was also evident where they incorporated various concerns raised by their peers by cross-referencing to Hong Kong and India (Both of which were British colonies too).

Findings and discussion

There were no entries that took the first two stances of level 1(Ignore) or level 2 (switch to opposing ideas in KB discourse). In fact, students even mentioned that they should not discount or be indifference to other comments (be it differing stands or areas of concerns). This is in sharp contrast to what the teacher experienced during the introductory session when students were noticed to be quick in either dismissing differing ideas or disregarding suggestions and comments.

The teacher also reflected that he was pleased to note that the students were not merely sharing information but mainly working towards synthesizing to derive at conceptual knowledge. The opportunities for this group of students to synthesize their initial ideas, question, research and build-on their peers' comments have very positive impact on students' engagement in historical reasoning. The study presented here shows how engaging in knowledge building discourse can help secondary school students build conceptual combination from diverse ideas for historical phenomena. The analysis also suggests that students are capable of engaging in such knowledge creation endeavor and they are genuinely interested in building collective understanding.

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Symposia

Toward a Multi-Level Knowledge Building Innovation Network

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Abstract: Knowledge building requires collaborative bootstrapping, with participants at all levels of the education system part of a collective effort to go beyond information exchange to innovation-producing networks that demonstrate that education can operate as a knowledge creating enterprise. Organizational theories and research are increasingly focused on multilevel perspectives for creating actionable knowledge; the challenge is to take advantage of emergence to self-organize around solutions and new means. By "innovation networks" we mean networks that go beyond sharing and discussion to the actual creation of new knowledge and innovations. Self-organization and emergence surround us, all the time and at multiple levels, whether we are aware or not. However, self-organization around idea improvement is rare and requires engaging innovative capacity at all levels, a research-intensive enterprise surrounding innovations, and an open source engineering team committed to enabling new forms of interaction, media, and analytic tools. "Multi-level" envisions inclusion of students, teachers, administrators, researchers, engineers, and policy makers in a collaborative enterprise. This session takes the form of a design think tank to advance conceptual frameworks and means for new and more powerful environments to support a multi-level knowledge building innovation network.

Introduction

According to OECD, networked communities of practice must together add up to an intertwined interconnected infrastructure at the system level (OECD, 2013). There are many networks in which teachers and sometimes administrators share experiences and practical ideas and discuss issues. However, they are not what Peter Gloor calls "innovation networks"—networks of people who not only share ideas but generate and refine new ideas through the dynamics of networked social interaction. Instead, according to Bryk, Gomez, and Grunow (2011, p. 135), education networks typically "function as free-floating idea bazaars, contexts for self-expression, and places 'to share.'"

Gloor identifies three forms of network engagement: (1) *Collaborative Innovation Network (COIN)*— a core team of self-organized and intrinsically self-motivated people who have a collective vision; (2) *Collaborative Learning Network (CLN)* - others who join the core community to discuss, learn, and apply innovations (DiMaggio, Gloor, & Passiante, 2009; Gloor, 2006); (3) *Collaborative Interest Network (CIN)*- those on the periphery, often lurkers, who do not contribute content but seem to have shared interests. These different forms of engagement create an innovation network ecosystem with spread of innovation from the core to periphery (Gloor, 2006). Innovations must occur throughout the extended virtual network, with people at the periphery in some contexts becoming innovators in another, with inward and outward flow of ideas and network boundary crossing—what in knowledge building we have referred to as *symmetric knowledge advancement*. Gloor, Fuehres, and Fischbach (2016) also identify repeat innovators across contexts as important for innovation networks.

More than two decades ago the knowledge building community initiated the Knowledge Society Network (KSN). Four sub-network structures were identified by Hong, Scardamalia, and Zhang (2010): intensive participant interaction, frequent idea interaction, emergent knowledge innovation, and sustained knowledge innovation. These have rough correspondence to Gloor's sub-networks. However, instead of working through networks, many knowledge building researchers have tended to work closely with teachers to co-design improved educational practices in their particular context—a one-on-one or one to small-group approach that is necessarily limited in scale. While the network helps to spread ideas, sustained innovation is limited due to insufficient time for engagement and demands for technological innovations that exceed the capacity of a small design team. In order to support a global innovation network and enable schools to operate as effective knowledge creating enterprises, an innovation network extensible to and adapted to the work patterns and the interests of all participants is needed.

The proposed think tank session features researchers, teachers, engineers, and policy makers spanning 10 nations, all committed to creating needed social and technological innovations. Toward this end the session will begin with a 30-minute presentation of a collective design document—a best effort on the part of the organizers to define social and technological innovations that will enable engagement in each country and be extensible to a much broader community. The immediate goal is to create infrastructure to enable forms of engagement that will allow us to establish a network through which we can address issues presented below. In an additional 30-minute session an overview of specific issues by various team members will be presented so that audience members can direct issues and questions to those with most relevant experience. The final half hour will be reserved for open audience participation.

Issues to be discussed

Inclusivity

The typical education network, like many online networks, consists of a relatively small number of active contributors plus a large number of "lurkers," who follow discussions but do not take active part in them. In innovation networks, as Gloor's research indicates, there is movement between innovation and lurker status. A truly inclusive network will need to afford intermediate possibilities that encourage full active participation without undue anxiety or need for assertiveness. It will also need to support coherent discourse across media and input, and opportunities for the most minimal of contributions to grow.

Sustainability

Sustainability is a major challenge and a critical feature in networks of all kinds (Sorensen, 2009). In some cases the problem is how to sustain a network after start-up funding ends, but in the case of a Knowledge Building innovation network, the more basic challenge is to sustain involvement and innovativeness. Achieving both of these depends on developing in the network a dynamic process that yields sufficient intrinsic rewards to participants to keep the network thriving. An issue that bears on both inclusivity and sustainability is that of funding necessary to provide central functions of technological and administrative support. Fees sustain some well-known initiatives, for example New Pedagogies for Deep Learning (http://npdl.global), but fees are not in the spirit of opportunistic, inclusive, scalable knowledge-creating enterprises.

Continual improvement

Given Knowledge Building's heavy emphasis on "collective cognitive responsibility for idea improvement" (Scardamalia, 2002), a Knowledge Building network is necessarily an "improvement network," as advocated by the Carnegie Foundation for the Advancement of Teaching (Bryk, Gomez, & Grunow, 2011). Ever since the pioneering work of Deming (1986) on continuous improvement, the importance of data and data-based goals has been recognized. A Knowledge Building innovation network needs cross-site data that enables participants to evaluate "how we are doing" with respect to shared goals and that also serves as a repository of rich qualitative information that can be mined for ideas and potential educational models. Such a database raises problems of comparability across sites and curricula, ethical approval, access rights, and language differences, besides the complex problem of anonymization. The potential of such a repository is enormous, however; it offers the prospect of doing for idea-centered education what the CHILDES *Child Language Data Exchange System*, (http://childes.psy.cmu.edu), has done for the study of language development. A fundamental issue that is more serious in an education network than in networks more oriented toward a "bottom line" is the relation between indicators and criteria. There are many well-recognized indicators of how well an educational innovation is doing, but there is also a high risk (as appeared in the NCLB drive toward continual improvement in a few kinds of test scores) that the indicator becomes a criterion, so that increasing standing on the indicators becomes the goal, displacing the actual educational goals that gave rise to the indicators.

Research-based innovation

Innovations in educational practice can come about through disciplined design-based research and also through teachers' efforts to solve educational problems or find a better way. A number of people in the Knowledge Building community are seeking a third approach that has researchers, practitioners, and engineers working together to produce innovations that combine the top-down character of theory-into-practice with the bottom-up character of innovations that originate in practice. A looked-for result is what Bereiter (2014) discussed as "principled practical knowledge"—knowledge that meets both criteria of practicality and criteria of explanatory coherence. The basic iterative mechanism of design-based research characterizes this knowledge-building process, but there is in addition investment in coherent justification and making generalizable sense of the emerging innovation. Beyond shared stories and research reports, the innovation networks must produce shared data to inform design iterations and test the effectiveness of Knowledge Building practices both in terms of knowledge building principles and in terms of generally recognized objectives of literacy, numeracy and what are popularly known as 21st century skills. Data should be helpful and convincing for the public and policy makers, as well as administrators and practitioners. Research-based advances must span elementary to tertiary sites, all subject areas, a broad range of socio-economic levels and sectors and include great cultural and linguistic diversity. Besides meeting these requirements, the data banks described previously should support graduate student research at all levels and enable match-making between practitioners and researchers to extend collaborative opportunities. The data repository should be the world's most valuable resource for studying knowledge creation in education, positioning the Knowledge Building design community to produce not only exportable "know-how" but to contribute significantly to knowledge of what students are capable of as junior members of a knowledge society. The data should provide a basis for models not only for education systems concerned about boosting basic skills but also for systems looking beyond test scores and '21st century skills' to what could increase cultural capacity to innovate, advance knowledge, and solve societal problems

Technology innovation, analytic tools and open source community

Collective goal: develop an educational software environment that mirrors conditions of the surrounding open, innovation-driven, knowledge society and that is maximally conducive to knowledge creation. The environment should

- make it possible for all citizens to be productively engaged in a knowledge building community
- incorporate analytic tools that provide support for sustained engagement leading to advances in knowledge and practice.
- support quality of group life rather than focus exclusively on individual achievement
- incorporate interface designs that make knowledge building activity transparent and adjustable as work proceeds.
- support "on the fly" visualizations that allow users to view their discourse from multiple perspectives, as part of the knowledge building process.
- support sustained creative work with ideas
- provide a scalable, cross-sector architecture to “rise above” idea fragments and clutter to powerful ideas
- include assessment to enable instant individual and group feedback to boost knowledge building and help users advance in basics, 21st century competencies and new competencies in parallel
- integrate face-to-face and online discourse into coherent knowledge-building/knowledge-creating dialogues

Open innovation

In “The Era of Open Innovation” Chesbrough (2003) states “the logic that supports an internally oriented, centralized approach to research and development (R&D) has become obsolete. Useful knowledge has become widespread and ideas must be used with alacrity. Such factors create a new logic of open innovation that embraces external ideas and knowledge in conjunction with internal R&D. This change offers novel ways to create value. …” As suggested in this quotation, successful enterprises are undergoing a fundamental shift from “closed innovation” to “open innovation” that takes advantage of an abundant resource—ideas—and communities able to move from promising ideas to useful innovations. Open innovation, as put into play by organizations ranging from technology companies to the U.S. Office of Education, requires two things not normally found in innovation networks: (1) openness to input from anywhere in the world rather than input limited by network participants, and (2) a central authority that defines problems to be put out for open innovation and evaluates and coordinates inputs from that process. The multi-level challenge of networking for educational innovation is therefore to exploit the strengths of three quite different forms of knowledge-creating interaction: local, small group collaboration in problem solving and design development; larger scale innovation networks; and still larger scale open innovation, where there are no restriction on where productive ideas and problem solutions come from.

Clearly not all these issues can be covered in the time available. The moderator will focus discussion on issues rising to prominence through ideas common to the presenters’ contributions and the audience response to them.

Significance of the symposium for the CSCL community and the CSCL 2017 theme

An important part of CSCL 2017’s “equity and access” theme is work that seeks “ways to broaden the CSCL pipeline.” Including the voices of teachers and other practitioners is a first-order requirement of such broadening. Many, perhaps most CSCL design researchers already include practitioners as active agents in the design process. This has certainly been true of Knowledge Building researchers for decades. However, giving practitioners a voice is not enough. Teachers and other practitioners represent a resource for innovation and invention that has proved difficult to integrate fully into design and engineering processes. Because Knowledge Building is a principles-based rather than a procedures-based approach (Hong & Sullivan, 2009), teachers’ creative input needs to extend beyond devising activities and implementation strategies. It needs to advance ways of improving the overall functioning of a classroom or other group as a knowledge-creating community. In order to do this within the large framework of Knowledge Building principles, practitioners themselves, along with researchers, engineers, administrators, and policymakers, need to function as a knowledge-creating community. Because the participants in this “think tank” symposium have pursued this objective in various ways over a number of years, they have the potential to produce design advances that will help the CSCL community as a whole in their pursuit of “equity and access.”

International panel and areas of expertise

Brazil

Cesar Nunes has implemented and evaluated large scale transformations on education including knowledge building communities involving teachers, policy makers and researchers and on subjects as diverse as moral development, creativity, and science. He is a researcher of the Moral Development Group at the University of Campinas, Brazil and consultant for OECD and Ayrton Senna Institute on programs for development and assessment of creativity and critical thinking.

Telma Vinha is professor at the Faculty of Education, University of Campinas –Unicamp-, Brazil. She leads the Moral Development Studies and Research Group and has been coordinating programs involving public and private schools around Brazil with the use of Knowledge Forum to connect Knowledge Building Principles and the development of student autonomy.

Canada

Marlene Scardamalia invented CSILE, the first networked collaborative learning environment and is active in all aspects of research on Knowledge Building and Knowledge Building technology. As holder of the Presidents' Chair in Education and Knowledge Technology at the University of Toronto, she has led an international network of researchers and innovators in education devoted to extending the limits of the possible in students' functioning as knowledge-creating communities.

Carl Bereiter is one of the originators of Knowledge Building as an educational approach and has been active in research related to it and to supportive technology design. His particular interest has been in the epistemological aspects of knowledge production (Bereiter, 2002, 2014, 2016).

Thérèse Laferrière, Chair, Centre of Research and Intervention for Student and School Success (CRI-SAS/CRIRES), Université Laval, a multi-university research center on successful schooling, is conducting a number of design research projects, including ones related to the Networked Remote School initiative, network-enabled communities of practice, and knowledge building communities. She is the lead researcher of a large network on school attendance and academic achievement named PERISCOPE, and funded by the Quebec main research funding agency (FRQ_SC).

Alexander (Sandy) McAuley is an Associate Professor at the Faculty of Education at the University of Prince Edward Island where he is the academic lead for the MEd cohort on 21st Century Teaching and Learning. He has been working with Knowledge Building in cross-cultural contexts, specifically in northern Canadian contexts, since the early 1990s and is particularly interested in its role in redressing the imbalances of power between marginalized and dominant groups in education.

Richard Reeve has worked in various capacities (teacher, teacher/researcher & faculty member) all oriented toward developing, sustaining and researching knowledge building communities in schools. As the original IKIT (Institute for Knowledge Innovation and Technology) teacher/researcher he became deeply interested in the role design plays in the implementation and development of innovative classroom practices. With his colleague Vanessa Svihla he has examined teacher discourse that supports this type of *designerly* work.

China

Shaoming Chai is an Associate Professor and Vice-Dean of the International Business School, South China Normal University, China. His research interests include computer-assisted language learning, online education, computer-supported collaborative learning, learning studies and technology, and international education.

Carol K.K. Chan (University of Hong Kong) has conducted research on knowledge building and has expertise in assessment in collaborative learning settings. Her work was recognized with the outstanding paper award at CSCL 2005. She is associate editor of the *International Journal of Computer-supported Collaborative Learning*.

Jan van Aalst is Associate Dean (Research), and Associate Professor at the Faculty of Education, The University of Hong Kong. His areas of expertise include: Knowledge building, formative assessment, inquiry-based learning. He is Associate Editor for the Journal of the Learning Sciences.

Colombia

Fernando Díaz del Castillo is Director of Innovation and Development at Gimnasio La Montaña, in Bogotá, Colombia. He leads the implementation of educational technology to scaffold innovation, and improve the quality of teaching, learning, assessment, as well as projects ranging from infrastructure renovations to international student exchanges and collaborations.

Finland

Kai Hakkarainen, Ph.D. (www.helsinki.academia.edu/KaiHakkarainen) is the professor of education at the Institute of Behavioral Sciences, University of Helsinki. With his colleagues, Hakkarainen has, for 20 years, investigated personal and collaborative learning processes at all levels, from elementary to higher education. From a strong theoretical basis he has addressed how learning and human intellectual resources can be expanded using collaborative technologies and personal and collective learning processes taking place in knowledge-intensive organizations, including innovative private corporations and academic research communities.

Pirita Seitamaa-Hakkarainen is Professor of Craft Science at the University of Helsinki, Department of Teacher Education. She has published studies in design and craft processes and practitioners' expertise in these areas. Moreover, she has had lead research projects for studying learning through collaborative designing and developed associated models and methods. Her investigations focus on creative processes involved in collaborative design activities as well as expert and teacher scaffolding of the process.

Japan

Yoshiaki Matsuzawa received his PhD in Media and Governance in 2008 from Keio University, Japan. He is an associate professor in the School of Social Informatics at Aoyama Gakuin University. Research interests include information systems design, computers as meta-media, and software development enabling change of learning. He is the initiating engineer for the current version of Knowledge Forum.

Jun Oshima has been involved in knowledge building research for more than twenty years, working in classroom at various levels in Japanese and advancing research on representing the state of collective knowledge advancement. In collaboration with engineering researchers, he developed Knowledge Building Discourse Explorer (KBDeX) for analyzing collaborative discourse in face-to-face and online communication.

Hajime Shirouzu is a director of Consortium for Renovating Education of the Future (http://coref.u-tokyo.ac.jp/en), which late Naomi Miyake founded nine years ago. Hajime and Naomi have collaborated with 2,000c teachers per year to introduce collaborative learning into ordinary classrooms in Japan.

The Netherlands

Frank de Jong has implemented knowledge building pedagogy in university education, business professional development, and currently in a two-year part-time MEd-program of Learning and Innovation of Aeres University of Applied sciences, Wageningen, the Netherlands. His current research is focused on responsive learning, the semiotic character of knowledge building conversations, and the development of semantic learning analytics.

Singapore

Seng Chee Tan is a deputy director of the Centre for Research and Development in Learning (CRADLE@NTU) at the Nanyang Technological University, Singapore. He has been working on knowledge building communities in Singaporean schools since 2002 and has edited the book "Knowledge Creation in Education" published by Springer in 2014.

Chew Lee Teo, is the Lead Specialist, Singapore Ministry of Education, working closely with teachers, heads of departments, and school leaders in principled adaptation of knowledge building. She connects teachers across Singapore in network knowledge building communities to establish idea-centered classrooms. She currently heads a group of specialists and teacher-researchers in exploring educational technology for active learning with technology in English Language, Chinese Language, Sciences, and the Humanities.

Spain

Mireia Montané is currently President of the World Federation of Associations for Teacher Education (WFATE) and director of the International Education Programs at the Col·legi de Doctors i Llicenciats in Catalonia, Spain. She is developing European Educational networks involving many European countries, and she is coordinator in Europe for the worldwide network KBIP (Knowledge Building International Network), using knowledge building theories between students, teachers and researches.

USA

Katerine Bielaczyc is the Director of the Hiatt Center for Urban Education at Clark University. Dr. Bielaczyc's research involves collaborating with students, teachers, and school communities to investigate new approaches to teaching and learning. Her work focuses on developing both technological and social infrastructures to support participants in working together as a knowledge building community to create knowledge regarding personal, pedagogical, and systemic transformation.

Bodong Chen is an Assistant Professor in learning technologies at the University of Minnesota. His primary interests include the design of new tools, analytics, and pedagogical supports to support higher-order competencies in knowledge building.

Mei-Hwa Chen, Mei-Hwa Chen is an Associate Professor at the Computer Science Department, University at Albany, State University of New York, USA. Her research interests include software architecture, software testing and reliability engineering. Dr. Chen leads the software engineering team that develops and maintains large-scale software applications in the education and the healthcare domains

Jianwei Zhang is an associate professor at the University at Albany. His research explores a principle-based, emergent structuration approach to supporting sustained knowledge building practices across classrooms. This approach is supported by the Idea Thread Mapper, a software tool designed to trace collective progress in extended online discourse, feedback on emergent structures, and connect idea threads across communities.

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Making a Difference: Analytics for Quality Knowledge-Building Conversations

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Abstract: The symposium focuses on the analysis of the knowledge building process e.g. idea improvement conversations by which students get to a high quality of knowledge and understanding. Learning Analytics (LA) focuses on the collection, measure and analysis of data about learners and their contexts (Long & Siemens, 2011). LA tools are normally rooted in probabilistic/frequency-based approaches. These are themselves incapable of capturing the meaning of texts at any level, because probabilities do not constitute natural language semantics. Therefore, semantic related analytics seems to be a promising approach. Not only to get insight in the process of knowledge building as a support for students and teachers in this collective process but also as a possibility for assessment. Not to control but to mirror and feed forward the semiotic collaborative process of building an understanding that makes a difference for how students look at and act in our world.

The overall focus of the symposium

The aim of the symposium is to explore how recent development in learning analytics (LA), especially semantic and network analytics, could afford new understandings of knowledge-building discourse, so as to broaden its access to more classrooms with less tradition of or less support for the Knowledge Building pedagogy (Scardamalia & Bereiter, 2014). Underlying this aim is another effort to turn decades of research on knowledge-building dialogues into actionable analytics, to form a solid basis for further development of analytics *for* instead of *of* knowledge building.

Knowledge building (Bereiter, 2002; Bereiter & Scardamalia, 2006a) or knowledge creation (Nonaka, 2006; Nonaka & Toyama, 2003; Nonaka, 1994) consists of the social and group dynamic processes as is the case in collaborative learning. However, the latter does not always include the systematic, methodological, hermeneutic process of knowledge creation as an enculturation in Popper's world 3 (Magee, 1974). Despite the affordances of collaborative learning formulations such as scripts (Dillenbourg & Hong, 2008), roles (Strijbos, 2004), or orchestrating graphs and workflows (Dillenbourg, 2015), they do not support such an enculturation as required for knowledge building. While tools in knowledge-building environments have been developed and continually refined to support such enculturation into World 3 (Scardamalia, 2004), LA introduces new opportunities to catalyze this same kind of development.

According to van Aalst, (2009, p. 260) knowledge creation involves more than the creation of new ideas; rather, it requires discourse (talk, writing, and other actions) to determine the limits of knowledge in the community, set goals, investigate problems, promote the impact of new ideas, and evaluate whether the state of knowledge in the community is advancing. It goes beyond the knowledge sharing among students, as well as "knowledge construction [that] refers to the processes by which students solve problems and construct understanding of concepts, phenomena, and situations" (p. 261). Knowledge creation, in contrast, involves the production and continual improvement of conceptual artifacts to solve authentic problems for community advance (Bereiter, 2002; Scardamalia & Bereiter, 2003). Knowledge building as a pedagogy engages students directly in the process of knowledge creation and help them "acquiring competence in knowledge creation by actually doing it" (Scardamalia & Bereiter, 2014, p. 399). Knowledge building derives from a Popperian epistemology and ontology (Bereiter, 2002; Scardamlia & Bereiter, 2014), with the Popperian ontological World 3 underlies the *semiotic process* in knowledge building. The World 3 enables knowledge production and sharing because we can grasp the knowledge in its form as a conceptual artefact, build on it, modify it, and develop it further. It concerns an objective knowledge world, created by the human mind. Students' thinking is related to their being-in-the-world and their mental mind(s) are embedded in their out-in-the-world artefacts.

Knowledge building as going into the artefact and the artefact getting into our minds is a process of transformation of our frame of reference. This process is a starting point for opening up our mind to perceive signs, codes and information as they manifest themselves in our problem, question, complexity. It is this semiotic process of noticing difference and potentials that we never perceived and understood before. *It is these kinds of knowledge building conversations with the others in the artefact, and with others about the artefact in which relations, e.g. differences come into language in the conversation (de Jong, 2015).* Not as an individual property of the interlocutors. 'What is', is 'laid down in the middle' as a 'rising above' in collective, in community, as a common language of collective understanding (a hermeneutic 'collective Verstehen'). The knowledge building conversation is not an adjusting to each other as partners in the conversation. Partners become engaged in the artefact, coming under the truth of the matter or praxis, under the resonation of understanding reality. A resonance of organic connectedness and dependency of our being as part of others and nature. Resonations that partners in the knowledge building conversation combine in a *new* common ground. In the 'knowledge-building-conversation' it is not merely against each other and putting your own positions forward, but a transformation into the common, into the collective. A transformation in which one does not remain who one was. (Gadamer, 1975, p. 360).

It is this *semiotic process* in which semantic learning analytics try to provide more empirically based insights. An approach that might be a basis for a direction of assessment. Instead of only assessing the grasp of facts it could move towards assessing the process of meaning making, thinking, and knowledge creation. Such an (formative) assessment by LA mirroring data and illuminating knowledge creation dynamics might help students in their process of thinking and becoming knowledge workers, and helps teachers to become knowledge building teachers.

This symposium addresses the question of how to develop these kinds of LA's to foster the support of assessment *for* students' understanding instead of assessing *of* students' learning and to support the students and teachers in the Knowledge Building process.

How contributions to the symposium are contributing to the aims?

The contribution from Zhang et al. shows how 'Idea Thread Mapper' explicate the idea threads as an inquiry of a shared epistemic object and the 'journey of thinking' mirrors the syntheses of the epistemic endeavor, the absences of knowledge to be addressed by the community, the interrelated strands of inquiry and student's participatory roles. The contribution of Velazquez et al. applies Natural Language Processing (NLP) techniques to analyzing the coverage of syllabus' vocabulary in students' conversations is evaluated using a method based on linguistic and cognitive knowledge. The analysis uses an asymmetric coverage hybrid measure, which combines semantic and lexical information with cognitive principles to determine how syllabus' concepts are covered in students' conversations. VandenEnde et al. study used the same students as Velazquez and integrates students' socio-cognitive openness, their use of curriculum keywords in the knowledge building and the alignment of keywords in students' term paper. The contribution of Chen attempts to integrate the activity theory with recent innovations in *dynamic network analysis* (DNA) to derive new indicators of knowledge-building discourse. The contribution from Chan et al. presents the Knowledge Connections Analyzer, a software designed to support students' self-assessment of asynchronous online discourse that emphasizes the collective aspects of knowledge building.

Idea Thread Mapper and its analytics tools: Tracing and connecting unfolding strands of inquiry across knowledge building communities

Jianwei Zhang, Mei-Hwa Chen, Feng Chen, and Carolyn Rosé

In a knowledge building community, students need to take on high-level collective responsibility for monitoring and continually advancing the "state of the art" of their collective knowledge (Scardamalia, 2002). Instead of simply dealing with teacher-assigned topics and tasks, students identify deepening goals as their knowledge advances through knowledge building discourse, and co-construct unfolding strands of inquiry to address shared goals. They co-engage in "dual construction" to both construct knowledge and the socio-epistemic structures of knowledge practices to guide and sustain their ongoing interactions (Hakkarainen, 2009; Zhang & Messina, 2010; Tao & Zhang, 2016). Current analytics and assessment tools mostly focus on features of specific idea entries in knowledge building discourse (e.g. words, problems, claims, evidence) (Mu et al., 2012). This paper presents our design and research of Idea Thread Mapper (ITM) (Zhang et al., 2012; Chen M.-H., Zhang, & Lee, 2013) that captures collective structures and unfolding strands of knowledge practices reflected in long-term online discourse in order to inform students' purposeful contributions and connected efforts.

On top of micro-level representations of ideas using online postings and build-on's (physical conversation threads), ITM incorporates "idea threads" as an emergent structure in online discourse. Each idea thread includes a sequence of discourse entries (possibly several build-on trees) that investigates a shared epistemic object of inquiry (e.g. conductors), as an unfolding strand of inquiry work (Zhang et al., 2007). Features of ITM signify collective structures of knowledge building including (a) using the thread topics and "Journey of Thinking" syntheses to highlight the shared epistemic objects being investigated and absences of knowledge to be addressed by the community; (b) using timeline-based discourse mapping to visualize the unfolding, interrelated strands of inquiry practices focusing on the epistemic objects; and (c) retrieving members' participatory roles in the different strands of inquiry. The collective landscape of a whole knowledge building initiative is mapped out as clusters of idea threads that investigate a set of interrelated problems through the contributions of all members. Visualization tools further show the intensity of contributions in each thread and cross-thread connections, including cross-thread build-on links and connective contributions that simultaneously address two or more objects of investigation.

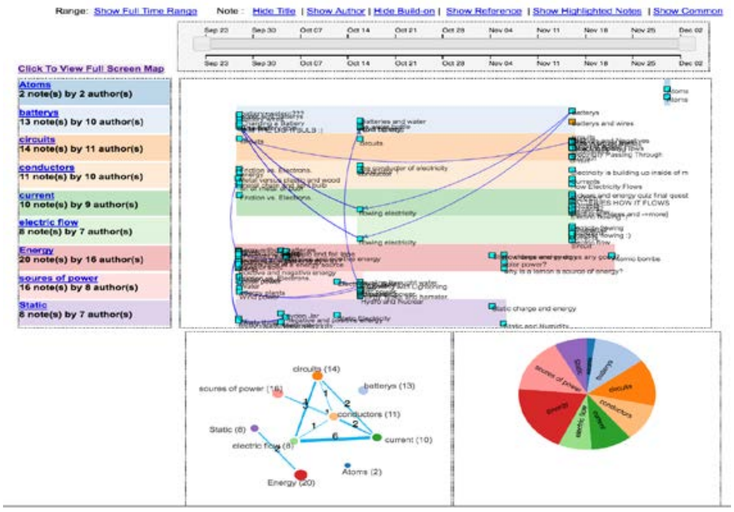

Figure 1. A map of idea threads created by a Grade 5/6 classroom studying electricity. Each colored stripe represents an idea thread extending from the first until the last note contributed. Each square represents a note; a blue line between two notes represents a build-on link. The example analyses (bottom) show the distribution of notes in the different idea threads and conceptual connections between the threads.

ITM integrates a set of automated analyses to support students' construction and review of idea threads in online discourse. Text analysis models set up using LightSIDE (formerly known as TagHelper — see Rosé et al., 2008) based on human-coded data can identify online discourse moves (contributions types) such as questioning (Kappa = .80), referencing sources (Kappa = .72), theorizing (Kappa = .68), and using evidence (Kappa = .52). An augmented Latent Dirichlet Allocation (LDA) tool retrieves topics from student online discourse in relation to topical structures of relevant expert texts (i.e. Wikipedia) and recommends online posts most relevant to each topic, as a potential idea thread. A cross-community space is further provided for students to share (publish) productive idea threads and "Journey of Thinking" syntheses across classrooms, with analytics of semantic similarity facilitating potential cross-community connection and complementarity.

ITM-supported classroom designs engage students in reflexive monitoring and structuring of knowledge building and formative assessment for collective and individual progress. A set of studies was conducted in third- through sixth-grade classrooms. The ITM-aided reflective monitoring and structuring of online discourse played a positive role in increasing student awareness of their community's evolving focus and collective progress, leading to more connected deepening moves to generate deep and coherent understandings (Chen, J. & Zhang, 2016; Tao et al., 2015; Zhang et al., 2015). Reviewing Journey of Thinking syntheses from other classrooms helped students to reflect on their own idea progress and gaps and further integrate insights from different communities for deeper research.

Analyzing students' knowledge-building conversations by comparing to syllabus and their collective writing

Erick Velazquez Godinez, Sylvie Ratté, Frank de Jong, Joan van den Ende, and Hennie van Heijst

Learning analytics (LA) has emerged during the past five years as a means to analyze mainly quantitatively the 'Learning' process. Mostly, LA focuses on frequencies of participations, contributions, amount of references, etc. (De Jong, 2015). Considering recent advances in Natural Language Processing (NLP) and Text-Mining (TM) techniques, it is now possible to incorporate new models within LA, to study the students' development of new concepts within knowledge-building dialogues. This, hence, provides an insight to both, teachers and students. Recent works on the analysis of learners' dialogues in CSCL platforms have shown that various linguistic and cognitive phenomena are involved in the learning processes (Dascalu et. all, 2015; Scheihing,et. all., 2016).

A lot of the works in computer science have been focused on similarity as a symmetric relation (Landauer, McNamara, Dennis, & Kintsch, 2007). These similarity measures were conceived in a symmetric way because of the use of geometric spaces, like Vector Space Model (VSM), and the bag of words model for cosine similarity in the context of NLP. When comparing two objects, A and B, in a coordinated space, this kind of similarity is symmetric because the distance is always the same from object A to object B and vice versa.

However, Tversky and Itamar (1978) standpoint is that similarity is an asymmetric relation, better described as a comparison of features (matching process) rather than a computation of metric distances between two points (Pinker, 2013). Tversky et. all. also, mentions that the concept of symmetric similarity should not be rejected altogether; it holds in many contexts, while in many others it is a useful approximation. He highlighted that symmetric similarity cannot be accepted as a universal principle of psychological similarity. Moreover, he shows that the concept of asymmetric similarity was observed in production tasks where we generate a similar response against single stimulus. Examples of these tasks are pattern recognition, stimulus identification, and word association.

An experiment was conducted, where conversations of four students in the Knowledge Forum were compared to the syllabus and a theme product. The syllabus is composed by 9 documents. These are all conference or journal articles. The theme product document is a collective document that the same group of students elaborated. The group consisted of 4 Med 'learning and innovating' students following the 3 month them 'visons on learning' as part of the 2 years' part time MEd 'learning and innovating' program. Students' years of age was 26, 24, 43. The two women students are teachers with many years of work experience the male student is director of an advisory enterprise in the field of 'ecology and landscaping'.

The conversations concern contributions of students in the Knowledge Forum environment. The number is different per student. The length of the contribution differs per contribution. The analysis concerns the use of concepts from the syllabus reflected in the students' conversations and their collective term paper, e.g. their conceptual artefact of their vison of learning conceptualized in a textual augmented visual model. The Dutch conversation data where translated with Google translate and corrected for spelling, typing errors etc. Stop-words were extracted. Finally, we face the problem of concept coverage by using a similarity text computation. For this we use the ACHM (Velasquez, Ratté, and de Jong, 2016). When comparing a syllabus text and a student's text, the ACHM allows selecting the word of the syllabus that contributes the most to the computation of the similarity process with the student text. This word is assumed to be the concept that ensures the connection between both segments of texts.

In analyzing the conversations versus the syllabus, a scatterplot is used to show the coverage value on the Y-axe. The X-axe represents the index of the student collaboration. The points that we can see for each student contributions in Fig. 2 (left) represent a different book from the syllabus. For example, the contribution one of the student 3 is almost aligned with almost all the syllabus document with a high degree of coverage. In more personal graphs like in Fig. 2 (right) the related articles of the syllabus of the concepts that are coming into the conversation of a student is presented. On the Y-axes, the index coverage is presented.

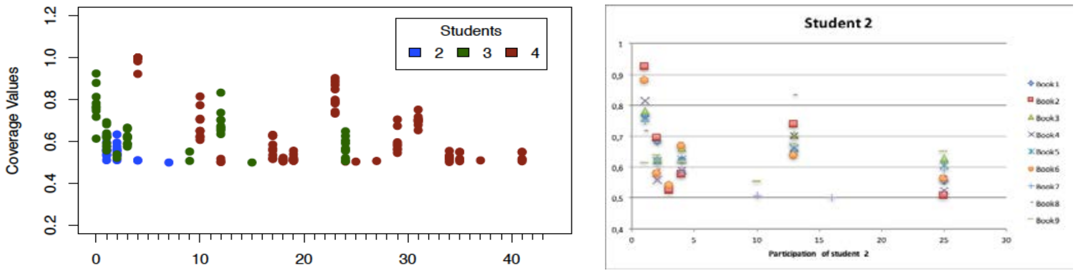

Figure 2. (left) Concentrated graph of student contributions and alignment with the syllabus; (Right) Dots express concepts from a particle syllabus article. On the Y-axes the similarity index and on the X-axes the contributions in time order.

The analysis shows the difference between students' contribution in the amount of similarity e.g. the covering of the syllabus' concepts by the conversations and the coverage of the term paper concepts by the conversations. This study gives insight in on the one hand in what way 'authoritative sources' contributes to the building understanding in the conversation and on the other hand how the conversations contribute to the term papers, e.g. the students' conceptual artefact concern their collective vison on learning.

Key concepts and socio-cognitive openness: Exploring the potential of knowledge building from the two perspectives

Joan van den Enden, Hennie van Heijst, Frank de Jong, Yoshiaki Matsuzawa, and Paul Kirschner

As teacher-researchers in an MEd program 'learning and innovating' we build our pedagogy on the principles of knowledge building and responsive learning (de Jong 2015). To improve our educational practices, we are constantly looking for more insight into how the knowledge building discourse in student communities fosters the development of a collective product (e.g., conceptual artifact; Bereiter 2002). To this end we conducted an in-depth case study on the knowledge building process of four students within a community of 28. These students are the same as in the Velazquez et al. study. We addressed the following questions: How do key concepts in the literature and in the collective term paper about a model of learning, enter and evolve in the knowledge building discourse. In this case study (N=4 students, 79 contributions in 19 conversation initiatives of which 12 developed; 3 rise aboves) we analyzed the: (1) emergence of key concepts in the online discourse itself, (2) use of key concepts in the final conceptual artifact, and (3) degree of socio-cognitive openness of the online discourse. For the key concepts we used KBDeX (Knowledge Building Discourse eXplorer), a tool to explore network structures of collaborative learning discourses in Knowledge Forum from the perspective of social as well as semantic analysis (Matsuzawa, Oshima, Oshima, Niihara, & Sakai, 2011). To analyze the degree of openness, we used a coding scheme based on CSCL-literature.

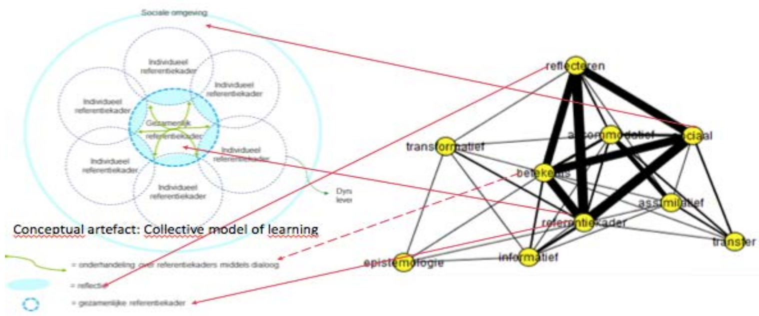

Figure 4. Alignment of key concepts in discourse and in collective term paper.

Conclusions: At the beginning stage at group level all key concepts appear and are loosely connected. There seems to be a fair amount of openness, although individual students show a diverse appearance of key concepts. During the process of knowledge building at group level, a selection of key concepts is firmly connected and a larger amount of openness is realized. More openness based on expression is showed at the individual student level; Students also show varying levels of uncertainty expressions. We determined an interaction with the degree of participation in the conversation. In the final stage, the selection of key words is slightly expanded at group level and can be easily recognized in the collective product, though the phrasings are different (see Fig. 4). The openness slightly diminishes except for orientation towards the other members. At the individual student level, student B develops the most strongly connected key words network, participates most and shows best balanced emergence of openness. Student C, who participated least, developed a scattered key words network but expressed greater openness. Student A participates at a 'medium' level and expresses least openness of all.

Deriving knowledge-building analytics through activity theory and dynamic network analysis

Bodong Chen, & Yoshiaki Matsuzawa

Knowledge Building (KB) is conceptualized as an interactive system involving epistemic agents (e.g., students, teachers), knowledge objects, and sociocultural practices (Chen & Hong, 2016), with KB principles (Scardamalia, 2002) explicating the relations among them to distinguish KB from other pedagogical approaches. For example, the principle of *Improvable Ideas* stresses the ontological substance of ideas, the commitment of epistemic agents to improve them, and the sociocultural norms of tolerating tentative ideas and continually improving them. To derive analytics for KB, therefore, efforts need to be geared towards understanding and interpreting the intricate relationships among agents, knowledge objects, and practices.

So far, much work has committed to the extraction of various measures from KB discourse (Burtis, 1998; Oshima, Oshima, & Matsuzawa, 2012; Zhang & Sun, 2011). While these techniques have shown promise in understanding KB discourse from unique angles, a more holistic approach that addresses the interactive KB system could contribute to the ongoing effort of developing KB analytics.

Among existent efforts to analyze KB discourse, the use of *activity theory* (Cole & Engeström, 1993) as an analytic framework represents a promising approach that "simultaneously" lights on multiple factors in KB discourse (Hewitt, 2004; van Aalst & Hill, 2006). Originating from Vygotsgy's work, activity theory attempts to bridge the space between *subjects* (e.g., students) and *objects* (e.g., tasks, problems of understanding) by recognizing various mediational means in between, i.e., *tools*, *rules*, *community*, and *division of labor* (Cole & Engeström, 1993). Compared to quantified content analysis widely applied to the analysis of KB discourse, the activity theory framework could afford a richer description of KB discourse, "because it accounts for both individual and communal activity, as well as multi-directional movement of individuals within the community" (van Aalst & Hill, 2016, p. 25).

During this session, we will present an emerging approach of operationalizing such activity-theory analysis through *dynamic network analysis* (DNA) and *rapid ethnographic assessment* (Carley, Bigrigg, & Diallo, 2012). Compared to a typical one-mode social network, a dynamic network is multi-mode (involving different types of nodes such as students and concepts) and multi-plex (comprising different kinds of links) network to capture different aspects of a KB activity system. Specifically, we first seek to construct a network representation of *subjects*, *objects*, *artifacts*, and *division of labor* (instructive to not cover *rules* and *community* for now) from trace data in Knowledge Forum; the resulting dynamic network is a holistic, theoretically-informed representation of KB discourse ready to be interpreted from different angles. Then, we can derive measures for different factors in the activity system, as well as the interactions among them. Using a simple example, we can derive a measure for *subjects* in a KB dialogue based on the count of Knowledge Forum activities from all students and the sum of connections they form with domain-specific concepts. This approach is distinctive from earlier work in CSCL that embraces a reductionist approach (Xing, Wadholm, Petakovic, & Goggins, 2015) or focuses on two-mode networks (Andrade, 2015).

A case study based on a secondary dataset (see Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007) will be presented, to afford opportunities for triangulation and validation. Analytic decisions will be critically examined, together with future development of this approach in machine learning, pedagogically responsive analytics, and information visualization for sense-making.

Using knowledge connection analyzer to scaffold reflective assessment in knowledge building

Carol Chan, Jan van Aalst, and Christine Yang

Knowledge building is a pioneer model in CSCL and an educational approach to initiate students into a knowledge creation culture (Scardamalia & Bereiter, 2014); a key idea is the contribution to the community for sustained idea improvement. At the heart of knowledge building is the online progressive discourse, supported by

Knowledge Forum® that help students maintain focus on idea improvement during their note-reading and note-writing as they work with ideas. Increased attention has been given to analysis of collective progress in knowledge forum discourse (Hong et al., 2015). Our goal is to employ the use of assessment and learning-analytics data in knowledge building for *formative assessment;* data extracted are to help students to self-assess and reflect on their discourse for progress. We present research using the Knowledge Connections Analyzer (KCA, Van Aalst et al. 2012), a software designed to support students' self-assessment of asynchronous online discourse that emphasizes the collective aspects of knowledge building (see Fig. 5).

A key goal of the KCA is to enable students to develop an understanding of knowledge building as involving effort and achievements at different levels—from the individual level to the community (or whole class). As pointed out by Stahl (2010), learning in a community produces *group cognition*, which is not reducible to the efforts of individual students. KCA attempts to help students understand and bring the collective aspects of knowledge building into focus. It is designed around four intuitive questions; students can run KCA and reflect on these questions: 1) Are we a community that collaborates (extent to which students are collaborating with others); 2) Are we putting our knowledge together? (use of reference notes in meta-discourse); 3) How does the community knowledge develop? (using keywords to identify key themes of community interests) and 4) What is happening to my own contributions? (tracking how own ideas develop over time) (Van Aalst et al., 2012)

We conducted initial research on KCA analyzing several Knowledge Forum databases drawn from the knowledge-building teacher network in Hong Kong (Chan, 2011), classified into two groups (Group 1: DB1, DB7, DB8, and DB9) and Group 2 (DB2, DB3, DB4, DB5, DB6); *analysis* shows that databases with stronger design work (i.e., principle-based portfolio) showed stronger KCA data on collaboration and rise-above compared to more novice teachers; the comparison data help validate KCA data and identify patterns where deeper knowledge work and conceptual synthesis are needed.

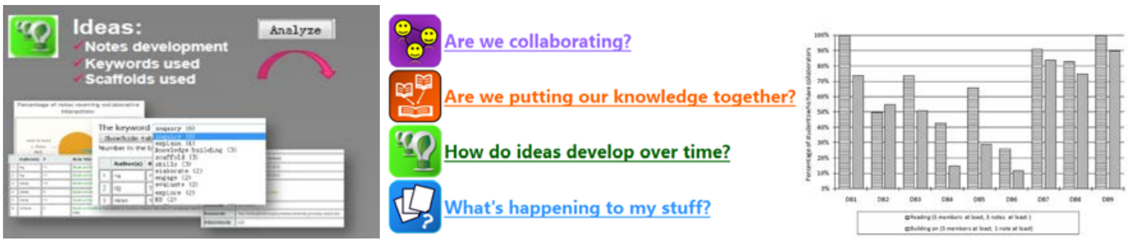

Figure 5. (Left and Middle) Features of Knowledge Connection Analyzer; (Right) KCA indices of community connectedness for nine databases with different intensity of pedagogical designs.

This study includes 32 grade-10 visual arts students working on knowledge building in a Hong Kong classroom. After the initial weeks on writing on Knowledge Forum, they were scaffold with the use of KCA to reflect on their KF discourse; it includes both teacher-researcher running KCA and students running KCA in groups to obtain data to track their own knowledge building work. Quantitative analysis shows how the use of KCA helped students to improve on Knowledge Forum discourse including the use of build-on and reference notes as well as qualitative coding of ideas showing more sophistication. Qualitative analysis of classroom discourse suggests how teacher scaffold students and how students engage in reflective assessment examining the gaps in current work, and in particular the collective aspects of knowledge building and how they could move forward (e.g., discussion on patterns of reference notes generated from KCA and need for more rise-above ideas). Knowledge-building talk and forum discourse have been the key areas of attention in knowledge building classrooms; the use of KCA additionally help students focus on data-driven improvement of discourse and transformative assessment as a collective cognitive responsibility.

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Technology and Applications for Collaborative Learning in Virtual Reality

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Abstract: In this symposium we explore the immense potential for virtual reality to be applied in educational settings. We discuss recent technological developments against a backdrop of several decades of research. Six presentations, including four from academic authors and two from the commercial sector, will explore user requirements, new technologies, and practical issues in collaborative VR applications for learning.

Focus and issues addressed

Virtual reality has long been touted for its potential to revolutionize education, with myriad advantages cited: access to remote experts, access to experiences that depend on scarce or access-limited resources (e.g. going to the moon), and access to experiences that are physically impossible (e.g. such as standing inside a molecule), to name a few. A new generation of consumer hardware has made this vision more in-reach than ever. In this symposium our interest is to understand what advantages of virtual reality in an educational context could or should bring it into practice in the classroom, and what factors will determine when and how this will happen.

Advantages named for collaborative virtual environments fall into two broad categories: those focused on the interaction with other humans, and those focused on the environment. The human interaction may be novel because of *who* one can interact with (e.g. remote people), or *how* one can interact (e.g. taking on a different physical appearance). The environment may be novel because it is based on a physical place that only few people can go, or because the experience it provides is inherently virtual (e.g. standing inside a molecule). In this symposium we present research that sheds light on past, present, and future efforts to realize these advantages in different contexts. The first presentation will provide a brief history of virtual reality and its applications to learning, culminating in the most recent wave of technology. The presentation of Cobb et al. will describe the application of non-immersive collaborative virtual environments to education of students with autism. In this case, the virtual environment provides a novel kind of interaction that is "safe" and structured in ways that the physical world is not, and this is leveraged in order to train social competencies such as collaboration. The presentation of Gouveia et al. will center around the successful introduction of a different kind of interactive technology in the classroom -- namely simulation-based virtual labs -- that provide a novel non-immersive virtual environment. Parallels will be drawn in order to shed light on what factors may determine the success of introducing virtual reality in the classroom in the coming years. The presentation of Kulik et al. will discuss technology-based research around multi-user interactions in novel immersive environments. This research has attempted to identify and support the most important attributes of collaborative group work in these settings. The presentation of Holland and Buessing will share early results from a large-scale effort to bring immersive collaborative virtual reality to the classroom. Finally, the presentation by Greenwald et al. will present technology-based research that explores non-verbal communication, collaborative creative expression, and the learning of abstract physical concepts in an immersive virtual environment. By bringing all of these threads of research together in a symposium, we hope to gain a clearer understanding of the landscape of challenges and opportunities related to virtual reality in formal and informal learning settings.

Then and now: Positioning a new wave of research on VR and learning

Scott W. Greenwald, Victoria Lee, and Alexander Kulik

This presentation provides a brief history of the technology and applications of virtual reality in the past several decades, including many involving training, education, and collaboration. The first wave of modern virtual reality took place during the 1960s. Philco Corporation created the first head-mounted display named "Headsight" which had a screen and tracking system and was linked to a closed-circuit TV. The intent behind "Headsight" was to train military personnel in tasks such as landing a high-speed aircraft, chemical and hazardous tests which could be watched from afar, or controlling a highly maneuverable submarine (Philco Corp, 2016). Although it was not connected to a computer, "Headsight" pioneered the practice of leveraging virtual reality technology for learning and training purposes. Soon thereafter, Ivan Sutherland developed the first head mounted stereo display to link with a computer instead of a camera to display images (Sutherland, 1968).

In the mid-1970s Myron Krueger created an interactive physical environment called "Videoplace" (Krueger). Instead of head-mounted displays, "Videoplace" used projectors and video cameras to support interaction, through the onscreen silhouettes of users. "Videoplace" demonstrated the potential of virtual environments for artistic and creative expression. Around the same time, the Wright-Patterson Air Force Base in Ohio continued what "Headlight" had begun, experimenting with virtual reality simulations for training and education. By the late 1980s, they had launched the "Super Cockpit" program, a virtual cockpit to train pilots (Lowood, 2016). Shortly after "Super Cockpit", NASA's Johnson Space Center began using head mounted display-based VR simulations to prepare astronauts. Although virtual reality was not widely adopted commercially following projects such as these, it played a crucial role in learning and training in these and several other niche areas, including further military applications, medical research, and other academic research.

Collaborative virtual environments (CVE) have a long history as well. Churchill and Snowdon published a thorough introduction to the topic in 1998 (Churchill 1998). They detailed the nature of collaborative and cooperative activities, and analyzed the realization of such behavior within networked virtual environments, using several examples from the time. Referring to research on behavioral psychology, they emphasized the relevance of nonverbal communication and indicated how this could be achieved in shared virtual environments - even using desktop-based systems with third-person viewpoints. Apparently, many learning goals can be effectively achieved in such settings (Dede, 1995; Cobb et al. 2010). Dede even argued that the synthetic and anonymous qualities of these early CVEs could have a positive effect on constructivist learning. However, this type of system was adopted more widely in entertainment rather than learning applications. Puppeteering a 3D avatar and monitoring others on a computer screen is less direct and intuitive than equivalent activities in an immersive 3D space. The attentional load required to operate the interface ties up cognitive resources that could otherwise be used for primary activities, such as learning. However, early collaborative immersive VR systems generally did not support embodied interaction and head-tracked egocentric viewing. One reason was that head-mounted displays hindered the perception of one's own body and those of others, while large 3D displays generally supported only a single stereo view.

A few early research prototypes implemented collocated collaborative augmented reality systems, where the virtual 3D content is spatially aligned with the physical interaction space. The "Studierstube", for example, used see-through head mounted displays for this purpose. A group of users could see the same 3D model and interact with it in context of their real environment (Szalavari et al., 1998; Schmalstieg et al., 2002). Hua et al. equipped multiple users with head-mounted projectors (Hua et al. 2003). The walls of their interaction space were covered with retroreflective materials such that each user saw their own personal perspective. Both projects also explored the use of multiple independent viewing windows to support varying levels of collaborative coupling.

Projection-based 3D display technology provides a different approach that has been extended for collaborative use as well. The two-user "Responsive Workbench", for example, showed four different images in sequence on a CRT projector at 144Hz (Agrawala et al., 1997). Barco combined time sequential image separation with polarization for two users with individual views at their "Virtual Surgery Table". The approach was later improved with shuttered LCD-projectors supporting up to four users (Fröhlich et al., 2005) and more recently with a DLP-based system supporting up to six users (Kulik et al., 2011). Moreover, several special-purpose multi-viewer displays have been proposed, based on separate display regions for each user's stereo view (Arthur et al., 1998; Kitamura et al., 2001; Bimber et al., 2001; Mulder and Boschker, 2004). The drawback of this approach is that it leads to a very small collaborative interaction space.

These and other systems have powered more recent studies that seek to better understand human behavior, learning, and collaboration. A few examples include: how a virtual learning environment benefits education (Huang et. al.; 2010), how virtual reality encourages helping behavior and interpersonal understanding (Ahn et. al., 2013), or the effectiveness of virtual reality and overcoming phobias (Garcia-Palacios et al., 2002).

In the past several years, virtual reality technology has experienced a resurgence. Innovations in the design and manufacturing of the relevant devices has led to the availability of cheap and robust VR hardware, including wide field-of-view, high-resolution headsets and submillimeter precision tracking technology. As of 2016, there were 43 million active users of virtual reality and that number is forecasted to grow, reaching 171 million by 2018 (Statista, 2016). When the era of personal computing expanded in the 1990s, a new generation of users, developers, and researchers emerged, and we propose that there is a parallel with what is happening now with virtual reality. Given the prior success of virtual reality in education and training for niche applications, we believe that the broader exploration of use cases, enabled by the new generation of hardware coupled with the power of the internet, will result in many more successes. It will empower educators and learners with new tools and a new medium, improving communication, collaboration, and co-creation.

Collaborative virtual reality for joint learning experiences

Alexander Kulik, André Kunert, Stephan Beck, Bernd Fröhlich

Virtual reality systems promote situated learning through the immersive experience of interactive objects, environments and processes. Egocentric 3D viewing supports self-paced data exploration and bears the potential to increase the users' identification with the topic at hand. However, head-mounted displays also decouple users' from the perception of their own body and their immediate physical and social environment. This in turn can hinder the comprehension of the displayed content. For example, it is commonly understood that depth perception is disturbed in virtual environments. However, representations of self and the immediate physical environment have been shown to ameliorate this effect (Interrante et al., 2008; Mohler et al., 2010; Phillips et al., 2010). Perhaps, comprehension can be understood as the establishment of robust relations between oneself and the topic of interest.

Moreover, learning is largely driven by exchange with peers. This can be particular relevant, if it comes to the interpretation of complex and ambiguous information. The immediate exchange between students can help to consider multiple perspectives and also to confirm the most probable interpretations. Direct interaction and mixed-initiative communication promote the ongoing discourse on a topic. We also learn by doing. Therefore, virtual environments for learning should be highly interactive. Ideally, multiple learners can interact jointly with the virtual environment and thereby reinforce their understandings. Support for joint action, however, must consider several planned and emergent coordination processes, all of which build on the spatiotemporal coherency of the shared interaction space (Knoblich et al., 2011). Gutwin and Greenberg highlighted how people achieve the necessary workspace awareness in physical environments through consequential communication, feedthrough, and intentional communication (Gutwin & Greenberg, 2002).

We believe that the unmitigated perception of self and others is a prerequisite for effective comprehension, learning and exchange. Therefore, we developed projection-based virtual reality systems that do not limit the users' perception of their immediate surroundings (i.e. workspace awareness), but that additionally provide them with multiple individual viewpoints towards a shared 3D scene (Kulik et al., 2011). The result is a coherent mixed reality of virtual objects, environments, and multiple collaborating users. We observe that direct mutual exchange about the digital content increases their relevance for users and supports mutual confirmation (Figure 1). Our studies show that users can build on body language and deictic gestures just as they do with real world objects and that collaborative visual search increases the understanding of all involved users (Salzmann et al., 2009; Kulik et al., 2011).

More recently, we extended these systems with support for remote collaboration of groups (Beck et al., 2013). Our group-to-group telepresence system captures users in real-time with clusters of color and depth cameras. The data is then transmitted over the network and the users can be reconstructed at life size in the shared virtual environment. These 3D video avatars are far from perfect, but they are perceived as an authentic dynamic representation of the remote collaborators' activities and appearances, which does not seem to induce uncanny feelings among participants. Our study showed that body language, in particular, deictic gestures and those to manage turn taking can be well supported with such a system. However, in direct comparison with collocated collaborators, the perceived co-presence of these avatars is limited (Figure 2). We are planning to study the effects of such mediators on social behavior and the effectiveness of collaborative learning with remote participants in virtual environments.

Figure 1. Two users discussing details of a combustion engine using a box-shaped cross section view.

Figure 2. Collaborative wayfinding in a telepresence setting. The remote user is captured and represented as a 3D video avatar in the virtual environment. (Vianden Castle model courtesy of ArcTron 3D)

As most collaborative actions, also learning requires certain levels of individual autonomy. It has been shown, for example, that brainstorming sessions can be ineffective if the setting does not allow participants to work alone and take individual responsibility (Sawyer, 2008, pp. 64-66). Therefore, interfaces for multi-user cooperation should support fluent transitions between individual activities and varying levels of collaborative coupling. Loose coupling can increase the diversity of contributions, while tight coupling is required to achieve mutual agreement and convergence towards intermediate resolutions. Support for territoriality as an emergent social behavior seems to be a pragmatic, yet powerful, design principle in that regard (Scott et al., 2004). User interfaces for collaborative learning should thus provide multiple interaction areas and support dynamic spatial restructuring (Figure 3; Kunert et al., 2014).

Figure 3. A large 3D powerwall (back) and a multitouch 3D tabletop (front) serve as independent multi-user 3D viewports into a shared virtual world. A virtual 3D display, or portal (center, with white frame), offers additional perspectives. The physical and virtual viewports serve for private interaction and group exchange.
Their combination in a coherent workspace supports fluent transitions between tightly and loosely coupled cooperation. Here, a multi-scale 3D scan of prehistoric rock art and its environment (Valcamonica, Italy) is explored.

Designing collaborative virtual environments for interaction and learning in children with autism.

Sue Cobb, Sarah Parsons, Nigel Newbutt

This presentation will use examples drawn from projects where we have developed applications using virtual reality technologies (VRTs) for children with autism. We plan to provide a context to the work we have completed in addition to a critical reflection and evaluation of involving stakeholders (teachers, students, related professionals) in the co-design and production of the materials, which are intended to be used in schools. The first project, COSPATIAL (2009-2012), developed collaborative virtual environments to encourage participation in social communication and collaboration amongst young people with autism. We focus on the Block Challenge game designed specifically to support student pairs in communicative perspective-taking and reciprocal co-operation in a collaborative block building task [Figure 1 and Figure 2] (Cobb et al. 2010) and present findings from an intervention study which suggest that CVEs can provide an educational context for learning and rehearsal of social communication, perspective-taking and reciprocity that can be effectively scaffolded by teachers (Parsons, 2015). The second project, VIRTAUT (2010-2013), sought to design a virtual world that would enable social skill opportunities, collaboration and participation in a virtual world via avatars and was implemented in a classroom-based setting [Figure 3 and Figure 4] (Newbutt, 2014). We will draw out specific examples where stakeholder involvement shaped the design and practice of using the virtual worlds in the classroom, was built in and the nature of working with autistic children.

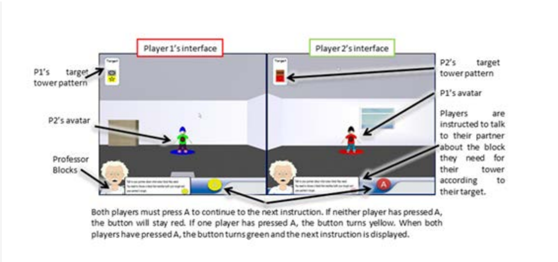

Figure 1. Each payer has a separate screen interface displaying their own avatar perspective within the virtual environment and the target block tower pattern that they need to build.

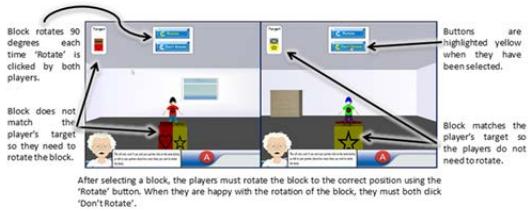

Figure 2. Building the tower to satisfy the different target patterns for each player requires communication, negotiation and collaborative interaction between the players.

Figure 3. The VIRTAUT collaborative virtual world provided a safe context for social interaction and communication between players.

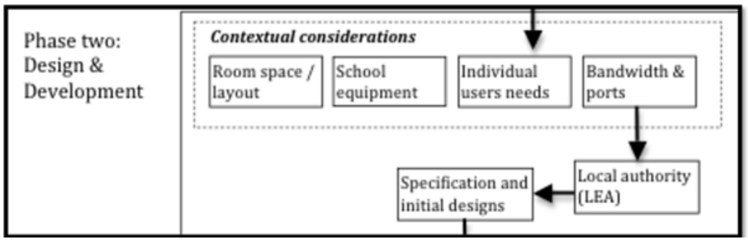

Figure 4. Involvement of educational stakeholders including both the school and local educational authority was important to identify contextual considerations to inform effective design.

In each of the projects the design process involved a variety of stakeholders each with different perspectives and objectives for the project outcomes. We will describe and reflect on the application of the 3T model of learner-centred design that determines CVE design based upon relevant learning Theory, Technology affordances and Thoughts (stakeholder-informed requirements) as a suitable framework to inform the design and development of educational technologies (Parsons and Cobb, 2014). In addition, the process of co-design identified various technological challenges with applying VRTs in situ (Newbutt, 2013). We will consider the opportunities and challenges of designing innovative technologies for special education, and specifically the affordances of VRTs for autistic user groups. In doing so we will consider ways to navigate these challenges and some best practice we have identified in design CVEs across the projects identified above. We hope to also highlight aspects of the design process that led to supporting interactions and learning in VR spaces. Future directions and priorities for research in this area will be presented.

"Nice to Have" to "Can't Do Without": Aligning simulations and VR with current needs in the K-12 classroom

Christine Gouveia, Claire Cook, Anne Snyder, and Scott Payne

How can immersive VR technologies be meaningfully and effectively incorporated into K-12 classroom instruction? To explore this question, we turn to a recent innovation that is closely related to immersive VR -- simulation-based lab activities for science instruction -- as an example of a technology that has been successfully integrated. Using these simulations as a case study, we examine the factors that have led to this success, and consider how they may inform the future of immersive VR technologies in a classroom context (Merchant et al., 2014; De Jong et al., 2013; Rutten et al., 2012; Toth et al., 2014).

For example, we ask: what learning experiences can a given technology enable that would not otherwise be possible using traditional approaches? Simulations and VR both have the potential to serve, not just as *adequate* substitutes for traditional / low-tech counterparts, but often as *superior* substitutes, when deployed in appropriate contexts and implemented in the right ways. We discuss the learning sciences research that both motivates and confirms the pedagogical value of simulations (and VR) for science learners; and we dig deeper into the practical considerations which help to propel its growing adoption among teachers. Among those practical considerations are those which bear on equity and access for K-12 learners. We argue that it is this parallelism between the pedagogical and practical which is key for an innovative alternative to take hold broadly and have staying power in a classroom context.

As developers continue to create and extend more sophisticated VR technologies, we survey the essential realities of the K-12 classroom that are important to consider, in order to ensure that emerging and evolving VR technologies solve a problem for users -- such that they will be broadly embraced and viewed as enabling essential learning experiences, rather than as fringe "add-ons" to more traditional curricula. We then invite participants to join us in examining what is perhaps the most important question of all: what problems can immersive VR technologies solve for K-12 teachers?

Principles, challenges, and lessons learned through developing a commercial platform for virtual reality in the classroom

Jennifer Holland and Shawn Buessing

Google Expeditions is a virtual reality teaching tool that lets you lead or join immersive virtual trips all over the world — get up close with historical landmarks, dive underwater with sharks, even visit outer space! Built for the classroom and small group use, Google Expeditions allows a teacher acting as a "guide" to lead classroom-sized groups of "explorers" through collections of 360° and 3D images while pointing out interesting sights along the way. We'll talk specifically about:

- Principles of educational content that we are finding effective for teachers of students
- Talk through why it's not easy to just repurpose legacy educational content into VR form and why many traditional educational publishers will have to rethink how they approach it
- Share specific examples and usage patterns in schools and countries
- Talk about specific hardware challenges with large group use of VR

Exploring same-time, same-place collaboration in room-scale virtual reality

Scott W. Greenwald, Wiley Corning, Gabriel Fields, Lei Xia

This presentation will summarize our explorations of same-time, same-place interaction in room-scale virtual reality with a focus on learning. As a baseline form of interaction, users are represented using minimal avatars in the virtual space in positions exactly corresponding to their actual physical positions. The avatars consist of semi-realistic representations of the headset and handheld controllers. The positions and orientations of these are updated to match their physical ones at 90Hz, giving their movement a very life-like appearance. My team has explored two different research questions related to this style of interaction. Firstly, we seek to understand the capacity of this medium (as described) to carry symbolic and emotive signals, typically carried not only by body gestures and movement, but also facial gestures and expressions. Second, we explore how one or more users can interact with and learn from simulation-based environments. This combination of questions is driven by the hypothesis that the combination of social and exploratory learning is particularly powerful in virtual reality.

We are currently developing an application, *CocoVerse*, which provides users with a suite of capabilities for creation and expression in a shared virtual environment. For example, users can draw volumetric shapes, add virtual objects and images to the environment and position them in space, write with speech-to-text, and take virtual snapshots and selfies. We structure this range of functionality within a set of discrete, easily-accessible tools, helping users to quickly learn and mentally compartmentalize the affordances available to them. In a learning application, teachers can lecture in 3D space for a live audience of students. Users can learn by interacting with simulated dynamics, or by exploring and annotating datasets or captured environments. Initial tests have shown the design to be learnable and usable. The modular codebase allows the application to be easily extended and customized to create domain-specific experiences, and we are collaborating with developers, instructors, and researchers to expand the set of use cases covered by our feature set, and identify cross-cutting design principles.

In order to explore how social learning works in a simulation-based environment, we selected a concrete use case -- a virtual reality physics environment, focused on university-level electricity and magnetism. The environment allows one or more people to explore the interaction of charged particles. In doing so, they gain insight into the dynamics of these interactions, as well as how these relate to the exact shape, form, and significance of the electric field generated by the particles. One of the general challenges in multi-user interactions with simulations is the sharing of control. In this case, where both users are free to place or drag charged particles in space, there are few conflicts to be concerned with -- the nature of the simulation lends itself to parallel interaction. One shared capability is the play/pause button that allows users to freeze the action of the system temporarily.

In our informal pilot studies, we identified some requirements related to the usage of such systems as a central element of curricular education. Although it is motivating and fun to interact with such a "playground," learners often require guidance in order to discover noteworthy phenomena or principles. We are exploring how to build scaffolding to balance guidance with self-direction for this use case.

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CSCL and Eye-tracking: Experiences, Opportunities and Challenges

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Abstract: The idea of using gaze as a medium to look into the collaborative processes had been around in CSCL for past few years. However, it had not been widely used in the community. Most of the works done in the direction of understanding collaborative cognition are majorly based on the qualitative methods. Research has shown that the collaborative gaze data can be used as an alternate source of information to assess collaboration. Once, we understand the how the gaze data reflects the collaboration quality and success, we could design gaze-aware systems to support remote/collocated collaboration. In this symposium, we bring together five papers that use eye-tracking data as a proxy for communication and cognition during remote/collocated collaborative learning and propose design of gaze-aware systems.

Keywords: eye-tracking, gaze-aware applications, modeling collaboration

Introduction

Eye-tracking has been used to explain the students' behavior in individual learning scenarios (Slykhuis et. al, 2005; Tsai et. al, 2012; Mayer, 2010). However, the use of eye-tracking in collaborative learning situations, more importantly in CSCL is rather uncommon. Findings of CSCL researchers have shown that eye-tracking can be equally useful to explain the collaborative learning processes as they are in individual learning cases.

Most of the methods employed to analyze and assess collaboration in CSCL are heavily based on qualitative methods. According to a review by Jeong and Hmelo-Silver (2010), 42% of the studies are based on qualitative analysis and/or "code and count" methods. These processes are tedious. Eye-tracking provides an automatic way of analyzing and assessing the collaboration, which could aid in gaining deeper and richer understanding of collaborative cognition. With the increasing number of eye-tracking studies, in collaborative settings, there is a need to create a shared body of knowledge about the relations found between gaze-based variables and cognitive constructs.

Eye-tracking has potential to be used in a wide subspace of CSCL "ecosystem", that is, different collaborative settings (remote or collocated); different learning instruments (multimedia, immersive or tangible); different learning formats (formal or informal); different planes (Dillenbourg et. al, 2011) in a classroom (individual, group, or the class); both sides of the instruction (teacher and/or student); tutoring systems and gaze-aware applications to support students in collaborative and/or individual settings. The use of eye-tracking will not only help us enriching our understanding about learning processes and relation of the gaze with the learning outcomes, but also proactively use students'/collaborators' gaze to inform them about their progress and mistakes.

In this symposium, the five papers cover the a large subset of CSCL "ecosystem", that is, remote and collocated collaborative settings, understanding teacher's orchestration, intelligent tutoring systems, and designing gaze-aware systems to support collaboration. The researchers will each present their work setting forth the conceptual, theoretical, practical advancements, and the challenges faced in eye-tracking research. The discussant will address how these papers have collectively advanced the chances of widening the use of eye-tracking in CSCL and analytics. The prime motivation of this symposium is to bring forward the findings, pitfalls, cautions, and challenges that appear while conducting eye-tracking research in CSCL and other formats of learning, to a wider range of audience, to present eye-tracking as an easy-to-go research tool; and finally, to burst the image of eye-trackers as a technology jargon.

Looking THROUGH versus looking AT

Kshitij Sharma, Patrick Jermann, Pierre Dillenbourg

Over multiple dual eye-tracking studies, researchers used dual eye-tracking as a proxy for cognition underlying collaboration. Richardson and Dale (2005), in a listening comprehension task, found that there was an eye-eye span (speaker's eye to listener's eye) of about 2 seconds. Jermann and Nüssli (2012) later confirmed this in a pair-programming task. There is a clear difference in the interaction styles of the teams that collaborate well in a given task and succeed; and the teams that do not and fail. In a collaborative program comprehension task Sharma et. al. (2012) found that the good pairs look at the data-flow of the program while the poor pairs read the program as if it was an English text. In the same study Sharma et. al, (2013) found that there is higher amount of similarity (probability to look at the same set of objects in the same time period) for the good pairs than that for the bad pairs. In a dual eye-tracking experiment, where participants first watched a video lecture individually and later collaboratively created a concept-map about the content of the lecture, we found that the participants who were individually following the teacher, both in deictic and dialogue space, more than the others, also had higher similarity during the collaborative concept-map task (Sharma et. al., 2015). These results indicate towards a common hypothesis that there exist two different ways of interacting with the content and the collaborator in a remote collaborative setting: "Looking THROUGH" and "Looking AT".

The concepts of "looking through" and "looking at" could be seen as new interaction style categories. "Looking at" the interface/display, indicates that the person is engaged with the material only, which is presented to him/her. "Looking through" the interface/display, indicates that the person is engaged with the peer. As an analogy, to high- light the difference between the two interaction styles, we can compare the interaction with the teacher/collaborating partner to watching a movie. "Looking at" can be compared with liking the movie; whereas, "looking through" can be compared with appreciating the director.

In a dual eye-tracking experiment with 120 students, as the first attempt to quantify these two interaction styles, we used two variables: "with-me-ness" (Sharma et. al., 2014) and " similarity" (Sharma et. al., 2013). The experimental task was to individually watch a video lecture first, and then to collaboratively create a concept map about the content of the video lecture.

With-me-ness is a measure for quantifying "how much are students following the teacher" during the video lectures. With-me-ness has two components: 1) perceptual with-me-ness and 2) conceptual with-me-ness. The perceptual with-me-ness captures the students' attention especially during the moments when the teacher makes explicit deictic gestures. Whereas, the conceptual with-me-ness captures whether and how much the student is following the teacher's dialogues. To compute conceptual with-me-ness, two authors mapped the teachers' dialogues to the different objects (objects of interest) on the screen. Once we have the objects of interest on the screen, we computed what proportion the dialogue length, (+2 seconds) in time, is spent by the participants on the objects of interest. This proportion is the measure of the conceptual with-me-ness.

Gaze similarity is the measure of how much the two participants in a pair were looking at the same thing at the same time or how similar their patterns were during a short period of time. To compute the similarity the whole interaction (during the collaborative concept map task) is divided into equal duration time windows. For each time window we compute a proportion vector, for each participant, containing the proportion of the window duration spent on each object of interest on the screen. Finally, the similarity is computed as the scalar product of the proportion vector for the two participants in a pair. Gaze similarity is a similar measure as the cross-recurrence proposed by Richardson and Dale (2005) but it is easier and faster to compute.

The results show a strong correlation between the average with-me-ness of the pair (during video lecture) and gaze similarity (during collaborative concept map). This suggests that there exist two categories of interaction styles: engaging with the material (looking at) or engaging with the peer (looking through). The peer in the video phase is the teacher and in the collaborative concept map is the collaborating partner. The "looking through" interaction resembles the social colocation of the interacting peers. A challenge for the next iteration of experiments would be to define semantic-less measures that could be applied to any context and not be restricted to video based instruction.

Gaze data on representational competencies in an intelligent tutor

Martina Rau, Zach Pardos

When students collaboratively solve problems in STEM, they often use visual representations (NRC, 2006). For example, students may collaboratively construct the visual representations shown in Figure 1 to solve chemistry problems. Students' difficulties with visual representations are well documented: they may not know how to interpret, construct, or reason with visual representations (for overviews, see [(Ainsworth, 2006). Thus, to benefit from visual representations, students need *representational competencies* that enable them to learn with visual representations (Rau, 2016). Representational competencies are particularly important for collaborative learning. First, visual representations can enhance collaboration quality by allowing students to externalize their reasoning, which helps establish common ground (Suthers & Hundhausen, 2003). Second, collaboration can help students make sense of visual representations because divergent views can prompt deeper engagement in sense making of representations (Gnesdilow, Bopardikar, Sullivan, & Puntambekar, 2010).

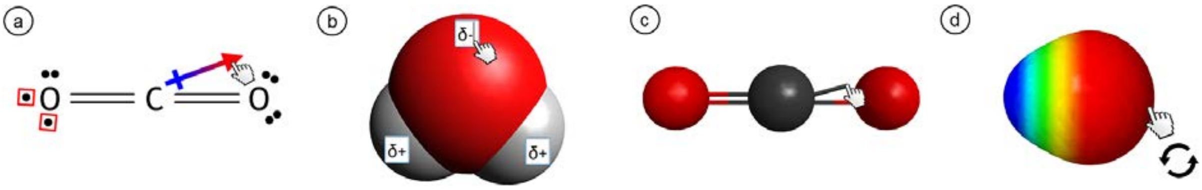

Figure 1. Visual representations in chemistry: a: Lewis structure; b: space-filling model; c: ball-and-stick model, d: EPM.

Intelligent tutoring systems (ITSs) offer several functionalities that can support collaborative problem solving, such as adaptive collaboration scripts (Walker, Rummel, & Koedinger, 2009) and just-in-time help and feedback (VanLehn, 2011). A new trend in research on ITSs is to support students' representational competencies (Rau, in press). ITSs adapt to students' needs for support based on a cognitive model that infers each student's knowledge level based on his/her interactions within the system (VanLehn, 2011). A limitation of current cognitive models is that they capture students' domain knowledge, not on representational competencies. Hence, current ITSs can adapt to domain knowledge but not to representational competencies. Yet, in light of the key role of representational competencies in STEM learning, providing support that adapts to students' representational competencies may significantly enhance the effectiveness of ITSs.

It seems reasonable to assume that we can gather useful information about students' representation competencies from their visual attention to representations. Prior eye-tracking research has several limitations that leave this question open. First, most prior eye-tracking research involved relatively simple learning materials (e.g., expository text paired with a static visual representation; [(Mason, Pluchino, Tornatora, & Ariasi, 2013; Mayer, 2010). By contrast, ITSs are more complex because they involve multiple interactive visual representations (see Figure 1). Second, prior eye-tracking research shows that eye- data improves the accuracy of cognitive models that assess students' domain knowledge [e.g., (Bondareva et al., 2013). Yet, cognitive models can use students' interactions to assess their representational competencies. It has not been tested whether eye- data can improve the accuracy of a cognitive model of representational competencies.

We found first indications that data might predict students' learning came in a study in which 25 undergraduate chemistry students worked with an ITS for chemistry. The ITS contained a cognitive model that captured students' representational competencies. Students worked with the ITS for 2.5h while a SMI RED 250 collected eye- data. Results showed that durations of students' fixations on visual representations predicted error rates obtained from the ITS log data, which in turn predicted students' learning outcomes on a domain-knowledge posttest. In a second study, we tested whether adding data to the ITS's cognitive model would enhance the model's accuracy in predicting students' errors when they solved problems within the ITS. 95 undergraduate students worked with the ITS for 3h. Results revealed no added benefit of adding eye- features (e.g., frequency of switching between representations, fixation durations in specific representations) to the cognitive model in terms of accuracy in predicting students' errors during problem solving. A limitation of this study was that the eye- features were available only at the level of the ITSs' problem, which contained multiple steps. Hence, in a third study, we tested whether more fine-grained eye- features at the level of problem-solving steps would improve the cognitive model's accuracy. 117 undergraduate students worked with the ITS for 3h. Results showed no added benefit of adding eye- data to the cognitive model.

Taken together, these findings stand in contrast to prior research that has found that eye- data can enhance the accuracy of cognitive models [e.g., (Bondareva et al., 2013). One important difference to our research is that our cognitive model assessed students' representational competencies. Hence, our findings may suggest that adding eye- data to a cognitive model that captures representational competencies based on students' interactions with visual representations. This rationale amounts to a new hypothesis that should be tested in future research: namely that adding representational competencies to a cognitive model of domain knowledge may improve the model's accuracy as much as the addition of eye- data would.

Dual eye-tracking in co-located spaces

Most dual eye-tracking studies remote collaborations involve two participants looking at two computer screens. This setup has a relatively low ecological validity, because most collaborative tasks still happen in co-located settings (e.g., face-to-face or side by side). Thus, it is difficult to know whether the results from remote collaborations actually generalize to co-located interactions. This gap in the literature is mostly the result of technical challenges: researchers can easily know whether two participants are looking at the same things on a screen, because the computer has perfect knowledge of what is displayed. In the real world, however, the computer has no knowledge of what is being captured by the camera of a mobile eye-tracker. Consequently, it is much more difficult to tell whether two participants are actually looking at the same location or not. In our own work (Schneider, Sharma, Cuendet, Zufferey, Dillenbourg & Pea, accepted), we have conducted an empirical study where apprentices in logistics (N=54) interacted with a Tangible User Interface (TUI). By leveraging the fiducial markers used by the TUI, we were able to remap students' s onto a ground truth (bottom half of Fig. 2, left side). This allowed us to replicate the results found in remote collaborations. We found that groups who had higher levels of joint visual attention tended to have a higher quality of collaboration, do better at the task given to them, and learn more from it. Additional results also suggested that students who used a 2D version of the TUI (i.e., with flat paper shelves instead of 3D shelves) tended to have less moments of JVA compared to students who used a 3D version of the tangible interface. While we are still investigating this effect, this result has interesting implications for designing collaborative interfaces: if one's goal is to support visual coordination in groups of students or collaborators, our findings suggest that 2D interfaces (such as computer screens, tablets) may not have the same affordances as environments that exhibit some 3D structure. Instead, 3D physical objects or environment might be best suited for collaborative work.

Dual eye-tracking datasets also allow researchers to identify particular group dynamics (Schneider, Sharma, Cuendet, Zufferey & Dillenbourg, 2016). Using the same dataset, we were able to first develop an enhanced version of a cross-recurrence graph. Two groups are contrasted on Figure 2 (right side): Both had high levels of JVA, but the group on the left had below average learning gains while the group on the right had above average learning gains. The top row shows the traditional cross-recurrence graph, while the middle rows shows our augmented version. Colors show where students had a moment of JVA (red means that participants were jointly looking at the leftmost warehouse on Fig. 2 (left side), green is for the warehouse in the middle and blue for the rightmost warehouse). Dotted squares indicate when the experimenter provided students with prompts. Color-coding offers insights about the strategies used by students: group 13 spent a lot of time going back and forth between warehouses, while group 20 focused on one model at the time. Since the goal was to identify design principles by *comparing* those layouts, it is not surprising that group 13 did better on the learning test. Finally, the bottom row of Fig. 2 (right side) shows speech data from each participant.

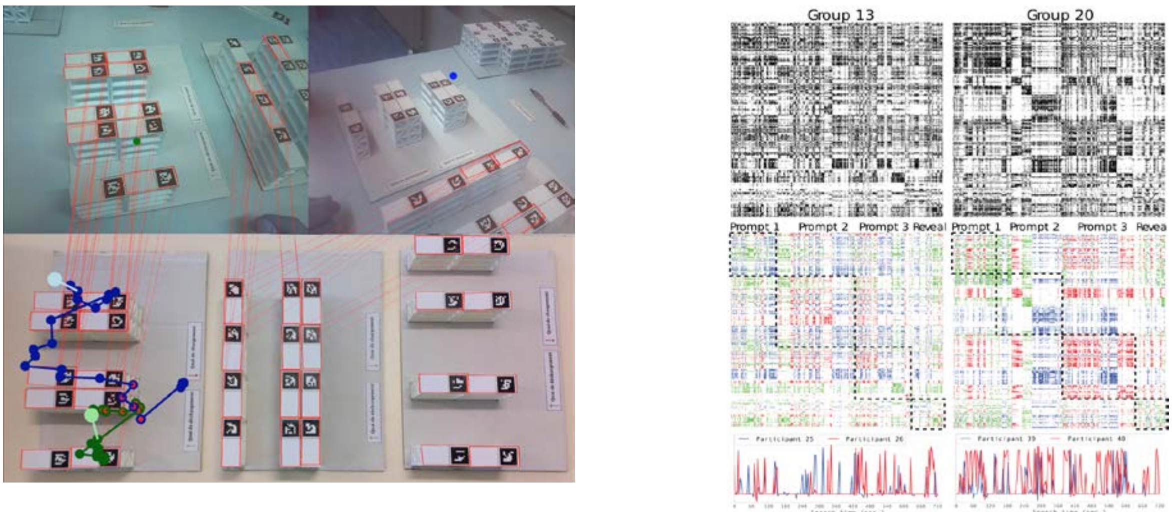

Figure 2. On the left: remapping two s onto a ground truth using two synchronized mobile eye-trackers. The top left image is the perspective of the first student, the top right image is the perspective of the second student, and the bottom image is the ground truth. Red dots show joint visual attention, and line between the three perspectives show common points used to remap students' s onto the ground truth. On the right: traditional cross-recurrence graphs (top), augmented with spatial information (red, green, blue) and speech (bottom).

In both groups, one participant (in red) tended to talk more while the other person (in blue) was quieter. By looking at the transcript, we realized that this pattern hid some crucial differences between those two groups. While the blue participant in group 20 would always agree with his partner, the blue participant in group 13 would constantly challenge his partner by pointing at counter-examples. So in one case, there was a clear free-rider effect where the more passive participant was intellectually disengaged from the activity. In the other group, the more passive student was actually actively contributing. We found that this pattern could be found in the eye-tracking data: for each moment of JVA, we identified who initiated it (i.e., whose was there first) and who responded to it (i.e., whose was there second). We found a significant correlation between learning gains and students' tendency to equally share the responsibility of initiating and responding to offers of JVA. In other words, groups where the same person always initiated moments of JVA were less likely to learn (e.g., group 20) and groups where this responsibility was evenly shared were more likely to learn (e.g., group 13). This finding shows that we can go beyond merely quantifying JVA, and actually identify (counter-) productive group dynamics using dual eye-tracking data in co-located settings.

In summary, there are some new interesting efforts pushing the boundaries of what has been previously done in the study of JVA. The first generation of studies was qualitative by nature, and used time-consuming analyses of videos to provide a detailed account of the micro-genesis of JVA (most notably with babies). The second generation started to use synchronized eye-trackers to quantitatively describes visual coordination and provide correlates of collaboration quality. We currently seeing a third wave of studies using synchronized eye-trackers, where those sensors are used to design interventions to support social interactions and where mobile eye-trackers are used to quantify JVA in co-located settings. Those new developments open new exciting doors to both capture and influence JVA in a variety of settings.

Designing representations for remote learning

Sarah D'Angelo and Darren Gergle

Integrating *awareness* into remote learning environments is one way to introduce missing non-verbal cues that are leveraged in effective co-located learning. This technique involves collecting eye movement data from people working on the same task and visually representing that information on screen for collaborators. Sharing patterns may be particularly helpful when remote teachers are explaining linguistically complex visual elements where it is difficult to create shared understanding. In dyadic interactions the basis of shared understanding is often the development of common ground among a pair. Explicit deictic gestures or references (e.g. pointing and saying "here") play a key role in establishing and maintaining common ground (Clark & Brennan, 1991). Therefore, a way to help students understand deictic references in remote environments is to display where the teacher is looking, because information can help the listeners better disambiguate deictic references in complex visual environments (Gergle & Clark, 2011; Hanna & Brennan, 2007). In this work, we explore displaying the teacher's information as a video augmentation to aid in understanding complex visual content and to help students follow along with the teacher, maintain attention, and model approaches used by experts when examining visual content.

We designed a video lecture on cloud identification that allowed us to evaluate the utility of video augmentations with highly visual and linguistically complex content. We evaluate two deixis visualizations (pointer and) in the context of a MOOC style video lecture on visually complex content (cloud identification). Deixis visualization is a representation of a physical gesturing (pointing with a pen) or a shift in attention (looking in a specific place) that is coupled with a deictic reference (e.g. "here"). The results suggest that showing the teacher's to students when making explicit references to information on the slides can be useful for students. When shown the teacher's information, students scored higher on the posttest compared to no visual aid. Additionally, students in the condition spent more time looking at relevant points and had similar patterns to the teacher. This suggests that the visualization helped students follow along with the lecture and helped them to look at the visual information in the appropriate way.

One possible explanation for this improvement in performance is the design of the visualization. We displayed the teacher's scan path, which highlights more areas on the slides by illustrating where the teacher was previously looking which would not be highlighted using pointer representation. This additional information may have helped students connect and integrate relevant information. In comparison, a recent study used a single point representation in a real-time collaborative learning exercise between peers. Their results show that awareness increased the partners' joint attention and improved gains in learning compared to no display (Schneider & Pea, 2013). This suggests that the design of visualizations can support the specific learning task. In a teacher to student learning task, a scan path representation helped students follow along with the teacher and learn appropriate eye movement patterns. On the other hand, in the collaborative learning study between peers, the single point representation helped students communicated about complex concepts. This raises the question; *how should representations be designed to effectively support different types of learning tasks*?

In this presentation, I will draw on results from my work and others as well as future directions to discuss the importance of creating effective visualizations of to support remote collaborative learning. For example, the degree of coupling between the pair might determine if continuous awareness is harmful or helpful (Brennan, Chen, Dickinson, Neider, & Zelinsky, 2008; D'Angelo & Gergle, 2016). Additionally, timing and distribution of knowledge can alter how pairs interpret another person's, which can illustrate a trajectory over time or a real time point of attention (Schneider & Pea, 2013; Stein & Brennan, 2004). Therefore, it is important to consider the features of the learning task when designing visual representations of to support effective collaboration between teachers and students.

Eye-tracking in CSCL orchestration research: Raw metrics and automation potential

Luis P. Prieto, Kshitij Sharma, Pierre Dillenbourg

Although CSCL puts most emphasis on learners and their interactions as crucial elements in learning, multiple studies (especially, in formal education settings) have highlighted the crucial role of teacher orchestration in its effectiveness (e.g., Onrubia & Engel, 2012). This has led to an interest in research about teacher orchestration of CSCL, both as an essential issue in the design of CSCL and other educational technologies (Dillenbourg et al., 2011) as well as in the process of implementing and evaluating CSCL innovations, taking into account the multiple constraints of everyday educational practice in authentic educational settings (Roschelle, Dimitriadis, & Hoppe, 2013).

Eye-tracking has been traditionally linked to lab studies in controlled conditions; recent advances in mobile eye-trackers (often in the form of wearable goggles) allow the study of eye movements in more natural settings. Indeed, such technologies are already being used in fields like human-computer interaction (HCI), usability engineering or marketing studies. The rest of this section describes two strands of research in which we have used such mobile eye-trackers to study the orchestration of learning (very often, CSCL) processes 'in the wild' (i.e., in authentic classroom settings).

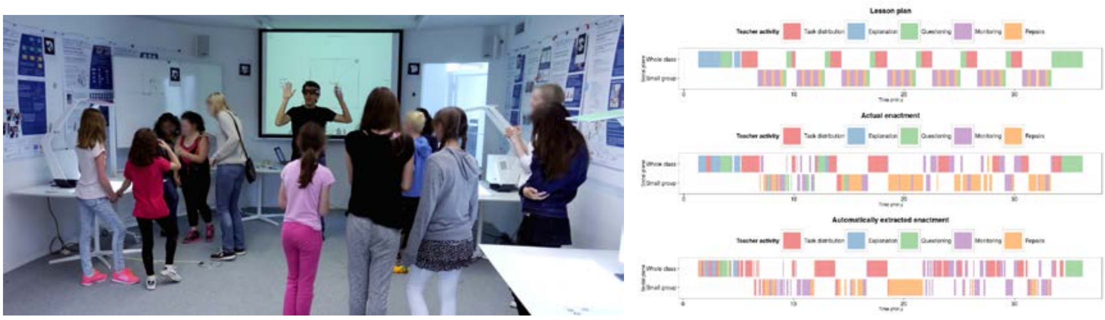

Figure 3. Classroom setup in one of the classroom studies to assess teacher's orchestration load through a mobile wearable eye-tracker (left, in the center of the image). Planned, human-coded and automatically coded orchestration graph of a collaborative learning lesson (right).

One of the main emphases of orchestration-related CSCL research is the technology design perspective: aside from being good for learners' outcomes, collaborative learning technologies that intend to be applied in everyday educational practice, have to be usable "at the classroom level" (Dillenbourg et al., 2011). That is, they also have to comply with multiple other restrictions of classroom settings, such as time or discipline constraints, or the limited cognitive resources of a teacher trying to keep track and support multiple collaborative learning processes at the same time (what some authors call 'orchestration load'). However, so far the output of this kind of research has been mainly in the form of abstract, high-level design principles distilled from the observation of isolated classroom experiments. The increasing availability of mobile eye-trackers, plus the work in psychology and HCI relating cognitive load and eye-related measures has the potential to provide a quantitative measure of orchestration load in real classroom environments. In our own work, we have explored the use of mobile eye-trackers to estimate teachers' orchestration load in diverse authentic classroom settings, from collaborative tabletop games to more usual laptop-based classrooms (e.g., Luis P. Prieto, Sharma, Wen, & Dillenbourg, 2015) (see Figure 3, left). Contrary to other contributions in this symposium, in this work we do not exploit so much *what* the subjects are looking at, but rather the raw, low-level physiological measures of *how* the teacher looks at students and classroom elements, which can provide insight into cognitive or even social aspects of teacher-student interactions in the orchestration of collaboration.

The aforementioned studies use (manual) video coding analyses to give context to the low-level raw measures of pupil and eye movement, and to add a semantic layer to the trends in these measures (e.g., what kind of episodes have tendency to be high-load or low-load). For instance, one of the noticeable trends in most of our studies is that class-level interactions tended to be high-load (as opposed to interactions with small groups of students). However interesting these results are for our understanding of the challenges in orchestrating CSCL processes, this manual coding makes it difficult to gather data at scale (e.g., in order to assess the generalizability of results) or apply the approach to the everyday practice of our schools. Recent advances in wearable and ubiquitous sensors, machine learning and computer vision, however, may help us to *automatically* infer certain aspects of the social and behavioral context of orchestration actions directly from the eye-tracker/sensor data. We have explored the feasibility of this approach to automate the coding of teaching activities and social planes of interaction (see Figure 3, right), obtaining reasonable levels of accuracy even with relatively simple algorithms and feature extraction (L.P. Prieto, Sharma, Dillenbourg, & Rodríguez-Triana, 2016). This emergent path of research (what we call 'multimodal teaching analytics') illustrates the potential of eye-tracking data for semi-automated analysis. Future advances in this kind of automation may in turn improve the scalability and reach of CSCL research efforts in authentic classroom conditions, both to improve our understanding of teacher decision-making and experience in the orchestration of CSCL processes (an under-developed area of research), and have direct applications for teacher education and professional development (e.g., through evidence-based reflection based on eye-tracking data gathered from everyday practice).

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Libraries as Emerging Spaces for Computer-Supported Collaborative Learning in Schools and Communities

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Abstract: Libraries are undergoing a reconceptualization in their roles as lifelong learning centers for local communities, with STEM content areas and Maker activities receiving special emphasis. This represents a critical and unique research, design, and partnership opportunity for learning scientists and computer-supported collaborative learning scholars. This symposium brings together project teams from four different locales in the United States that have partnered with libraries to bring about new resources and activities that emphasize computer-supported collaborative learning. These projects represent major urban libraries, special collections, community branch libraries, and school libraries. By bringing together these different teams, this symposium aims to promote dialogue about the affordances and constraints associated with CSCL-oriented activity design in libraries, identify commonalities and differences across region and library types, and ground-truth what specific challenges and solutions have been identified in researcher-library partnerships.

Introduction

A national push has been made for libraries to reconceptualize their role as centers for lifelong learning, with STEM content areas and Maker activities receiving special emphasis (Palfrey, 2015). In response, libraries are beginning to offer new programs, spaces, technologies, and activities that emphasize patron authorship, expression, and exploration. One prominent model of this has been *YouMedia* at the Harold Washington Library in Chicago (Barron, Gomez, Pinkard, & Martin, 2014), which served as a youth-oriented digital media and CSCL space where youth interests, technology-infused practices, and identities were actively explored and promoted. Such models have become aspirational examples that many other libraries now strive to emulate. The image of the library is transforming from a quiet repository of books to a noisy and active learning space.

This represents a critical and unique opportunity for learning scientists, educational technologists, and computer-supported collaborative learning scholars. Libraries have long been one of the most democratic institutions in American society; they provide access to information and space for anyone regardless of background, socioeconomic status, or prior experience. Those ideals are ones that communities would like to see maintained as libraries also take on the role of technologically-enhanced lifelong STEM learning centers. As mentioned above, some aspirational models exist, but learning scientists have long recognized that an aspiration is not enough. Partnerships, informed design processes, and critical reflection are also critical ingredients for enhancing the design of any learning space or experience. This awareness is deeply embedded into the history of the learning sciences and CSCL communities, who have pioneered design-based research as a means for simultaneously understanding and improving existing learning spaces.

In following with the 2017 CSCL conference theme of "Making a difference: Prioritizing equity and access in CSCL", this symposium brings together design-based research teams from four different regions of the country who have all recognized that libraries are beginning to take on this new role and are welcoming new research and design-oriented partners to pave the way for new kinds STEM learning. Although the contributors to this symposium represent a set of geographically dispersed scholars pursuing different projects, we are all deeply committed to the idea that libraries should remain highly accessible and equity-promoting learning institutions. By coming together for this session, we hope to accomplish several goals. First, through describing our distinct projects, we seek to demonstrate how libraries represent important partners for new lines of computer-supported collaborative learning research. Stated simply, we intend to greatly increase the list of exemplary library-based computer-supported collaborative learning activities and experiences. Second, we seek to highlight commonalities and differences that exist when conducting design-based research with libraries through the juxtaposition of the different library-based projects. Libraries exist in many forms and in many locales, suggesting that there may be some common points of leverage along with specific situation-based considerations that library-based research-practice partnerships must consider. Our goal is to articulate unique affordances of libraries as CSCL spaces. Third, we intend to offer some ground-truth about what challenges exist for researchers and library personnel who embark on design partnerships. While we believe libraries offer clear affordances that differ from other researched learning spaces (such as schools, virtual environments, and museums), we also recognize that libraries have unique constraints such as personnel who may not be trained in STEM areas, limited contact time with patrons, and other existing obligations as a community center. These three goals are discussed by each set of presenters.

The symposium is organized such that the chair will first give some brief, introductory remarks about the emerging opportunity to conduct learning sciences work with libraries in the United States. Then each of four separate but related talks will describe a specific library partnership and design-based research project. Included in the talks will be explicit discussion of the three goals (illustrating the partnership potential for libraries as sites for CSCL, discussing commonalities and differences across library types and sites, and ground-truthing the specific challenges and workarounds in researcher-library partnerships). The types of libraries represented vary, with two talks focusing on large urban libraries in major metropolitan areas (Tzou, et al.) and one of those emphasizing the Special Collections Division of their library (Kahn & Hall), one talk focusing on various branch offices located in different neighborhoods of a large city (Kafai, et al.), and one talk focusing on middle school libraries (Phillips, et al.). To help synthesize across the talks and to help facilitate discussion, Brigid Barron of Stanford university will serve as a discussant and discussion moderator. Barron is especially suited to this task as her research with the Digital Youth Network (Barron, Gomez, Pinkard, & Martin, 2014) and in looking at learning across contexts (Barron, 2006)) provides her with a valuable complementary perspective to some of the issues that we discuss.

The four talks from the various research and design partnerships are detailed in the text below.

Family-centered social arrangements for Making in library contexts

Carrie Tzou, University of Washington, Bothell; Megan Bang, Philip Bell, Shelley Stromholt, Nancy Price and Meixi Ng, University of Washington, Seattle

The Backpacks for Family Learning Partnership

Our project is a cultural psychological design-based research study (Bang, 2015; Bell, 2004) that involves a research-practice partnership between a large university, a large urban library system, an Indigenous youth organization, and a science center. In this project, we are exploring ways of engaging families from non-dominant communities in a STEAM workshop series focused on learning robotics and programming in the context of an arts/design project approach. We center robotics learning within the context of family histories and stories in an attempt to focus on families as "cultural, historical, and political actors" (Vossoughi et al., 2016).

The Backpacks project invites parents to take on new roles as learners with their children while they learn about programming, engineering design processes, and related science concepts. At the same time, family members are also invited to draw on their own areas of expertise—in traditional practices such as sewing or professional skills such as computer programming. Literature in the study of equity in education indicates the need to tightly interconnect learning that occurs across settings (homes, community settings, and schools) and that "learning is facilitated when the cultural, socio-economic, and historical contexts of learners are recognized, respected, and responded to" (Banks, et al, 2007, p. 25; Bell et al., 2012). The use of the storytelling frame for contextualizing the robotics development project was a deliberate design strategy to: tie into cultural practices around storytelling, connect to families' personal and cultural histories, and leverage the unique professional expertise of librarians (especially youth and children's librarians) in connecting people with stories. We leverage the significant reading and storytelling expertise of librarians while we support them to learn about STEM knowledge and practices.

Family-centered designs for consequential STEAM learning and identification

The overarching design effort is focused on creating a sequence of designed experiences—including robotics development and e-textiles projects—to support families in expansive STEAM learning across workshop events and settings. The project is currently exploring two major design strategies. *First, how can family workshops promote intergenerational STEAM learning?* We developed and enacted family-centered program multiple times in two locations—one community site facilitated by the library and an Indigenous cultural community site facilitated by their program facilitators. *Second, how can a robotics backpack materially support learning across settings between program sessions?* This is a 'material resourcing' design strategy to support family learning and identification between the formal program sessions. In the current workshops, families construct a robotic diorama that animates and communicates a family story of their choosing.

Unique affordances of Making in a library-centered context

Our analysis focused on: (a) *different social and material configurations of families* as they jointly accomplished their robotic dioramas—along with their interactions with facilitators, (b) *reflective practices of librarians* learning to facilitate these sessions. Data sources included ethnographic observations and video recordings of sessions, session engagement surveys, pre/post workshop family interviews, and pre/post workshop surveys were analyzed for this paper. Several findings highlight unique affordances of the library-centered context. *First*, the storytelling and art/design frames on robotics/STEAM learning opened up multiple, oftentimes parallel spaces for families to purposefully explore and play with devices and programming to achieve desired effects—and that family members can pursue their own interests and perceived areas of expertise within the project. It allowed for specialization and collective creation—for example, one child programming a "twinkle" into an LED, one child constructing a cloud, a parent using "fiber optic" plastic to combine all of these to make a "shooting star" effect in a night sky. To this end, librarians were able to leverage their formal grounding in storytelling and literacy practices to frame their teaching and family support in the design work—while learning about STEM, circuit design, programming, etc. *Second*, the reflective practice of librarians was coordinated with the pedagogical reflection practice of the researchers. This developed into a standing practice for librarians to author full session reflections that went far beyond the facilitator reflection sessions instituted by the project. This led to tighter coordination across the partnership and more rapid cycles of pedagogical improvement across sessions than previously documented.

Challenges for Making in a library-centered context

Expert librarians have deep expertise in supporting the culturally diverse public with their information requests, but they do not consider themselves to be teachers—and they are, in general, adverse to being positioned as such. This introduces a deep enactment tension in the project in that facilitators need to interpret and shape learning processes of families using pedagogical principles and practices—as expert teachers do. A second challenge relates to the strong structuring of public librarians (e.g., fixed schedules and responsibilities; union contract strictures) relative to the flexibility needed to schedule program experiences for youth from non-dominant communities. The tension can be managed, but it is an ongoing implementation tension that we discuss in our presentation.

Connected messages: Mentor support of youth agency in designing interactive community murals in local branches of public libraries

Yasmin Kafai and Orkan Telhan, University of Pennsylvania; Richard Davis, Stanford University; K-Fai Steele, National Writing Project; and Barrie Adleberg, Connected Sparks

As public libraries are expanding their mission beyond books and computer access to include youth programming and maker activities (Subramaniam, Ahn, Fleischmann, & Druin, 2012), they are facing additional challenges of serving the specific needs, interests, and community involvements in their local branches. Most library maker activities promote projects where youth work on individual designs while being in the library space. Few activities have been designed to leverage the existing network of multiple branch libraries to foster collaboration between makers. We present the design and implementation of *Connected Messages*, an interactive community mural at branches of The Free Library of Philadelphia, as an example of a computer-supported collaborative maker environment. We examined youth agency and mentor support in accessing, participating, and expressing their community ideas and concerns by asking the following questions: (1) What impacts youth participation in and expression of community themes at different library branches? And (2) How can mentors support youth voice, making, and technical learning in community-relevant designs?

The Connected Messages project

In the *Connected Messages* project we provided augmented community displays that were local to their branches but controllable via the Internet by others across the city. Each of the five participating library branches received a physical mural that was made out of a piece of foam core with a grid of copper tape (see Figure 1). This created a DIY circuit board, which allowed for the placement of 64 individual cardboard boxes. Each box had a transparent top decorated by youth with messages relevant to them and their community. The youth also assembled the circuit on the bottom of the box that, once placed on the grid, allowed others via a web interface to turn on or off a LED placed in the middle. These boxes that each youth made individually were used to create the larger interactive community mural (Figure 1). A total of 1,036 youth, between ages 6-19 years, participated in the project over a two-month time period, their daily participation fluctuating from three to thirty participants, in five Free Library locations in underserved neighborhoods across North and West Philadelphia. The mural activities were led by five Maker Mentors, a team that consisted of three men and two women, ages 21-31, with backgrounds as working artists and undergraduate students. Field notes and photographs served as primary means of documenting artifacts and interactions.

Figure 1. (1) Color pencils used for individual designs, (2) Single box prototype with LED light and decorative drawing, (3) Boxes mounted on the foam board, (4) Electric imp, copper tape connections, and LED matrix controller, and (5) Five boards connected to a mural with some LEDs turned on each board.

Findings and features of the library branch settings

We found that youth participation, access, themes, and completion of the community mural designs for *Connected Messages* project differed substantially at neighborhood branches and illustrated some of the challenges in implementing such collective projects across different locations of the public library, albeit located in the same city. For example, the theme at one branch was "City of Brotherly Love and Sisterly Affection." The themes of many boxes of these youth reflected daily conversations about crime, violence, and society that are prominent and near-daily events in their neighborhoods: "I wrote this PEACE sign and I wrote we all are brothers and sisters and I wrote it because so we can stop violence and shootings" as well as the importance of self-acceptance "LOVE yourself". This branch had 15-16 regular participants, ages 13-19, as part of an intervention program.

In contrast, at another branch in North Philadelphia, youth aged 7-15 participated in making the message boxes around themes of positive things in the community, and things that youth like to do during the summer in their neighborhood. The board was completed within one week and displayed prominently on the library main floor to generate curiosity and interest by the library community and staff and would be "something that they can be proud of and see and that will last." At a different branch the board was locked in a conference room and youth ages 6-16 were only able to populate it with message boxes when the mentor came around three times a week. Message themes focused on community, friends and family. With no repeat visits to this site, many message boxes ended up not being connected to the board.

In our presentation, we will discuss how working with different branches made salient how libraries within the same system differ in how they appropriate a project like *Connected Messages*. Local neighborhood features and how different branches manage access to resources for youth both represent important considerations for CSCL work even when a single library system has been established as an overarching project partner.

Data wrangling and family storytelling at the city public library

Jennifer Kahn and Rogers Hall, Vanderbilt University

We describe design-based research developed in partnership with the Special Collections Division of the City Public Library in Nashville. Special Collections' mission is to record a public history that is both inclusive and representative of the city's increasingly diverse demographics. They regularly bring youth into library spaces to engage in critical, transdisciplinary inquiry projects (i.e., spatial analysis and modeling of historical phenomena at multiple social scales). Our partnership with the Special Collections Division seeks to design and study innovative learning activities through which youth come to view themselves as participants and contributors to the city's living public history. We report a cycle of design-based research in which youth build and tell "family data storylines" at the library. Youth curated personal family history while exploring public, large-scale socioeconomic datasets using online, data visualization tools. In our presentation, we report on how we investigated the ways in which integrating local and family history with aggregate data invited the telling of powerful stories about oneself and society, and how the library provided a unique space for transdisciplinary, computer-supported collaborative learning (CSCL).

Large-scale data sets in libraries

Large-scale datasets (LSDS), also known as "big data", comprise a sociotechnical phenomenon that has advanced the interdisciplinary fields of data science, analysis, and visualization (Busch, 2014). With the growth of open big data and digital tools, the cost of modeling with LSDS has decreased and consequently generated new practices for analyzing and tackling socioeconomic and scientific problems (Venturini, Jensen, & Latour, 2015). Our collaboration with the City Public Library has been committed to creating opportunities for youth to develop and deepen relations to the city and relevant LSDS through storytelling, mapping, and modeling activities. The library was an important site because it serves as a place for family and community gathering. Libraries are also amenable to a "pop up" model, making many aspects of programs designed in one library replicable to other libraries and public community spaces.

Our project approached modeling as storytelling about society (Becker, 2007), drawing on critical social theories of pedagogy (Friere, 1970) that view narrative as a medium for amplifying voices and leveraging the lived experiences of historically marginalized and underrepresented communities (Milner & Howard, 2013; Solórzano & Yosso, 2001). The library and Special Collections staff had been an important partnership because it similarly shared commitments to strengthening and providing public outlets for community voices—and, in particular, the voices of historically underrepresented community members. This made for an opportune partnership.

Design and data collection activities

Our design study asked: *How does scaling personal experiences into aggregate data facilitate learning to critically model and tell stories about oneself and society?* Our focus on the relationship between local, personal experiences, and aggregate trends draws from an earlier design study iteration (Kahn & Hall, 2016) that found that *getting personal* with the data in modeling activity—shifting across scales of time, space, and social life in discourse and model animation—facilitates critical perspectives towards the social, economic, and historical issues described by the big data.

Figure 2. Two teens using SocialExplorer to lead their parents in exploring US Census Data at the City Library.

In order to learn more about how getting personal could foster critical inquiry and youth learning to model and tell stories about society with big data, our design study of experimental teaching at the library explicitly framed the activity around a relation between the individual and the aggregate. This past summer, we asked (N=17) diverse middle and high school youth (ages 10–16, with six sibling pairs) in a free workshop (2–4 days, 5 hours each day) at the City Public Library over 3 weeks to assemble *family data storylines* to explore reasons for migration nationally and globally (i.e., "What moves families?") and personally (i.e., "What moved *my* family?"). Participants used one of two online, public modeling tools: Gapminder.org, a free, web-based dynamic data visualization tool that uses public global socioeconomic data, or SocialExplorer.com, a historical thematic mapping tool that accesses US demographic (US Census) data, authorized by the public library (Figure 2). Participants assembled their family data storylines in Microsoft PowerPoint, which were then displayed in a community exhibit to their families. We video and audio recorded all workshop activities; all student work on computers was recorded with screen capture software. Participants also contributed oral histories about their family mobility histories or *geobiographies* to the library's archives.

Current analysis and findings

Interaction analyses (Jordan & Henderson, 1995) of video records and field notes indicate that participants viewed data tools as useful for discovery. Participants performed a range of comparisons that involved scaling time, space, and social life. To do this, they engaged with *data wrangling*, practices that manage multiple datasets and measures in order to align the family story with the aggregate data. The broad accessibility of the library space for extended family members became an important resource for youth learning. As youth began to develop family data storylines, they negotiated co-telling with siblings, many of whom were in the workshop, and parents—via phone calls, parent visits during the workshop day, and at-home conversations over intervening nights and days. We also have found that scaling personal stories to the social aggregate is richly complex. While telling their personal family histories, the teens' contrasted their experiences with that of their parents or grandparents; however, that distance appears to collapse as the teens, their siblings, and their older family members become a singular unit for comparison with the social history described by the data. Ongoing analysis further examines how modeling with census data affects one's understanding of the family and how the teens' accounts of their family history and broader social history compare to those of their parents when youth and parents jointly gather at the library.

Librarians in transition: Investigating CSCL potentials within the school library

Abigail Phillips, Victor R. Lee, Jennifer Hansen, and Mimi Recker, Utah State University

Of the nearly 120,000 libraries in the United States, the vast majority of them (over 98,000) are school libraries (American Library Association, 2015). As with other types of libraries discussed in this symposium, school libraries are reconceptualizing what kinds of learning activities should take place (e.g., Preddy, 2013), including an emphasis on leveraging them as environments for open-ended STEM learning activities (Subramaniam, Ahn, Fleischmann, & Druin, 2012). Yet we know little about how school libraries will also be able to evolve into spaces that support computer-supported collaborative learning. In contrast to other forms of brick-and-mortar libraries (e.g., public community libraries, academic libraries), those housed in schools focus exclusively on providing services and resources for youth at their immediate site. That specificity provides a unique opportunity for focused programming and learning experiences that cater to a common age group and align with ongoing classroom-based instruction. At the same time, school librarians work in uniquely challenging environments because they typically have at most a single staff person managing all operations and are bound by a rigid class schedule that necessarily limits contact time between the librarian and any visiting youth. Furthermore, a tension exists between the role of librarian as facilitator of student-led learning activities and the librarian as another adult instructor employed by the school.

Studying and supporting school librarians with Making

With an overall goal of fostering library-based computer-supported collaborative learning activities associated with Making (Bequette et al, 2013)., we have embarked on a multi-year research-practice partnership (Coburn et al. 2013) that seeks to understand and engage with the challenges faced by library professionals when they experience an organizational push to support new forms of Maker-oriented learning in their spaces. Because school libraries are an understudied facet of a complex formal educational system, our first task has been to understand the problems of practice faced by librarians and jointly envision new opportunities and practices toward improvement. We report on analyses of written observation and audiorecorded interview data from all the middle school librarians working in a single rural school district (N=4, district population approximately 16,000).

Themes and tensions related to school libraries as spaces for Making

From examination and qualitative coding of our data, we have identified the following themes and tensions as they relate to envisioning libraries as CSCL learning environments:

- *Tension 1: Where tool expertise resides with respect to a school library*. We observed that some librarians viewed one aspect of their job as providing a space for youth who already patronize their library and know much more about new technologies and new software environments than they do. These librarians find this advanced knowledge to be an enabler of youth-driven collaborative learning. Their expectation is for the youth to teach each other when new activities or resources are added. If existing youth experts were not already accessible, then the librarians would charge student aides to become advanced novices so that new technologies could still be used and appropriated by youth. As conceived, one librarian saw her primary job as publicizing the availability of new tools or software and then letting the youth shape how interaction norms will take place. On the other hand, some librarians felt they must be accountable for knowing how any new tool works and did not want to introduce activities that use these tools until they themselves are adequately proficient. New technologies that appeared complicated or required significant overhead, even though they may be a rich enabler of computer-supported collaborative learning, were less preferred or otherwise faced resistance.

- *Tension 2: How the school library overlaps with what takes place in classrooms.* In one interview activity, the librarians assessed the feasibility and imagined use of new Maker technologies by youth in their spaces. A few librarians recognized some technologies (e.g., the Sphero programmable robot-ball) as being ones that other faculty and staff (e.g., computing education teacher) at their school already owned. This raised concerns about how to avoid imposing on others' "territory". In some cases, the librarians envisioned partnerships with those subject matter teachers such that structured learning activities would take place in the classroom under the instructional plans of that teacher and then extended within the library. Additional duplicates of materials and learning resources would then reside at the school library. Youth would come in during lunch and afterschool to teach one another and 'mess around' (Ito, et al., 2010) beyond what their classroom teachers allowed. In other cases, while some novel activities involving overlapping technologies could be imagined, the librarians expressed concern that they did not want to offend other school employees and preferred not to have such resources or activities in the library so as to not be perceived as usurping what instructional innovations another teacher was introducing.

Figure 3. Some school libraries have opted to maintain orderly arrangements (left) while others are encouraging smaller gathering spaces (center) and encouraging gaming and recreational device and computer use (right).

- *Tension 3: How students should behave in the library.* Libraries are traditionally conceived as quiet spaces with books. We observed some spaces that were designed to be orderly and open (Figure 3), with ample long tables and seats within clear view of the librarian to ensure that youth were quiet and refrained from disrupting the experiences of other youth patrons. Other librarians seemed to design their libraries as a sort of "third place" for youth (Oldenburg, 1999). This involved having smaller enclaves, comfy couches, and providing access to secluded rooms so friends could gather, put their feet up, use mobile devices, and "game". One librarian of this disposition explicitly stated that in her view, her school library should be "a noisy place".

These tensions represent just a sampling of how school librarians organize the spaces that they occupy and how they envision learning activities for the future. Given that school libraries are expected to transform themselves as learning spaces and follow the lead of innovative public library CSCL media spaces, these tensions begin to establish regions in the design space for school libraries. We posit that school librarians that already expect that they will host distributed youth expertise, collaborations with teachers, and some inherent disorder will have the easiest transition. However, that remains to be understood and clarified as our partnership with school libraries continues to develop and moves into iterative implementation phases in the future.

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Collaborative Problem Solving: Innovating Standardized Assessment

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Abstract: In this symposium, we present the overall design, data, and scientific findings from the ETS Collaborative Science Assessment Prototype (ECSAP). We are opening our data to the CSCL community and introducing the procedures to request access to the data. ECSAP was developed to explore the assessment of collaborative problem solving (CPS) competency through a large-scale and standardized approach. The goal of this symposium is to examine research questions that are of interest to the CSCL community, such as how CPS skills and collaborative patterns interact with performance outcomes, and how prior content knowledge and personality of team members affect the collaboration process and outcomes. In our study, we collected both individual and collaborative responses (~1500 responses) to the ECSAP instruments. We present our study findings that used new methodologies in psychometrics and followed the best practices of psychometrics and statistics.

Introduction

In contemporary networked and technology-mediated knowledge economies, collaborative problem solving becomes a critical competency for college and career readiness and has been used extensively by educators at all levels. The majority of research on CPS has focused on learning, for example, finding effective ways to promote learning in a (computerized) collaborative environment (Stahl et al., 2006) or developing interventions to foster collaboration skills that contribute to improved learning (Sottilare et al., 2012). However, the assessment aspect of CPS has been relatively less researched. Among the existing studies on assessing CPS, most of them are designed from the perspective of revealing important aspects of CPS (Cohen et al., 1999; DeChurch and Mesmer-Magnus, 2010; O'Neil, 2014; Woolley et al., 2010) based on small samples of participants (von Davier & Halpin, 2013). Many studies collected data from small groups of participants based on convenience, and often did not use standardized assessments in which assessment items, scoring procedures, and interpretations were consistent across test forms. The convenience sampling and the non-standardized instruments in these studies motivate questions about possible bias and the reproducibility of the findings (Hao, Liu, von Davier & Kyllonen, in press).

Among the existing large-scale assessments for CPS, both human-agent (Graesser, Dowell, Clewley, & Shaffer, 2016) and human-human collaborations have been used. In the CPS tasks developed for the *Programme for International Student Assessment* (PISA) in its sixth survey during 2015 (OECD 2013), students collaborated with a different number of virtual partners (agents) on a set of computer-based collaborative tasks and communicated with their virtual partners by choosing from a list of predefined texts. The use of virtual agent and predefined texts is a compromise from a person-to-person collaboration made to ensure standardization, which may pose threats to the validity of assessing collaboration. Another notable assessment for CPS (albeit not standardized) was developed for the Assessment and Teaching of 21st Century Skills project (ATC21S) carried out by Griffin and colleagues (Griffin et al., 2012). In this assessment, two students collaborated via text chat to solve computer-based collaborative tasks. Their actions and response time were automatically coded according to a CPS framework (Adams et al., 2015). Both PISA 2015 and ATC21S consider CPS as a competency that holds across a wide range of domains. In our research, we built off both PISA and ATC21S work and developed ECSAP to explore the assessment of CPS in the domain of science via large-scale data collection and standardized assessment instruments (Liu, Hao, von Davier & Kyllonen, 2015; Hao, Liu, von Davier & Kyllonen, 2015). The ECSAP consists of three assessment instruments to measure the general science knowledge, personality, and CPS. It also includes a background information survey and an after collaboration survey. In this symposium, we bring together a collection of four papers to describe the design of

ECSAP as well as a series of studies to explore several research questions that are of interest to the CSCL field, such as how CPS skills and collaborative patterns interact with collaboration outcomes, and how prior content knowledge and personality of team members affect the collaboration process and outcomes. In presentation 1, we provide an overview of the assessment design and data product from ECSAP. In presentation 2, we introduce a CPS framework that supported the assessment design and discourse analyses. In presentation 3, we present a novel approach for modeling interaction patterns and show how they affect the collaboration outcomes. In presentation 4, we explore how the general science knowledge and team members' personality affect the collaboration outcomes. Our discussant, Dr. Art Graesser, will address how the papers collectively advance CPS assessment in a standardized way and identify gaps in current research and implications for future work.

Presentation 1: ECSAP design and data

Jiangang Hao, Lei Liu, Jessica J. Andrews, Alina A. von Davier, Mengxiao Zhu, and Patrick Kyllonen

The ECSAP was developed to address three major research questions based on large-scale data: identify constructs of CPS and collaboration patterns in the domain of science; find out how the collaborative process affects the collaboration outcome; and explore how the team members' content-relevant knowledge and their personalities affect the collaboration process and outcome. As we are aiming at addressing these questions with large-scale data, we have to compromise on several things to make it practically feasible. For example, to reduce the confounding factors and alleviate the privacy concerns, we chose to use the text-mediated communication rather than video/audio-mediated communication. More details about how we have addressed the practical challenges can be found in Hao, Liu, von Davier, & Kyllonen (in press). There are five instruments in the ECSAP as shown in Figure 1.

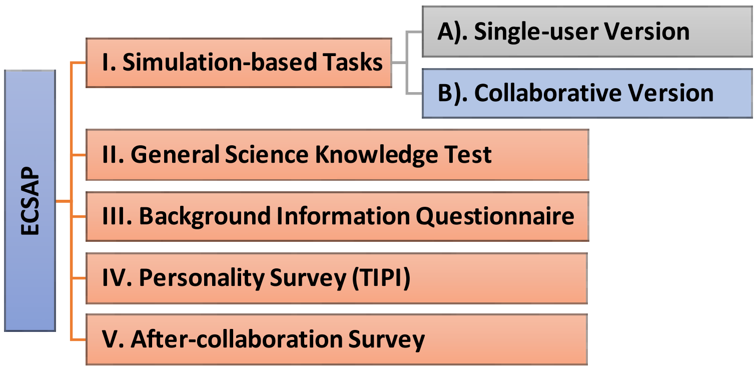

Figure 1. Instruments included in the ECSAP.

The assessment instruments II - V are self-explanatory by name. The simulation-based tasks are modified from an existing game-like science assessment (see details in Zapata-Rivera et al., 2014) in which students work with two virtual agents (a virtual scientist and virtual peer) to solve a complex science problem about making predictions about volcanic eruptions using a dialogue engine. Figure 2 shows the screenshots from the single-user and collaborative versions of the simulation tasks. In the collaborative version of the simulation, students interacted through a chat box. In addition, we designed structured system prompts (based on our CPS framework) to facilitate the collaborative discourse between dyad participants. For each question, we first ask each member of the team to respond the question individually. Then we ask them to collaborate with each other to discuss their answer choices. After collaboration, each member is given a chance to revise his/her initial response. The difference between the initial and revised response captures the gain of the person from the collaboration. Based on the change, we considered the collaboration as effective as long as at least one member made at least a total net change from incorrect to correct. If nobody in the team made at least one total net correct change, we thought of the collaboration as ineffective (Hao, Liu, von Davier, Kyllonen, & Kitchen, 2016). As shown in the second presentation, the effective and ineffective collaboration correspond to different CPS skill profiles.

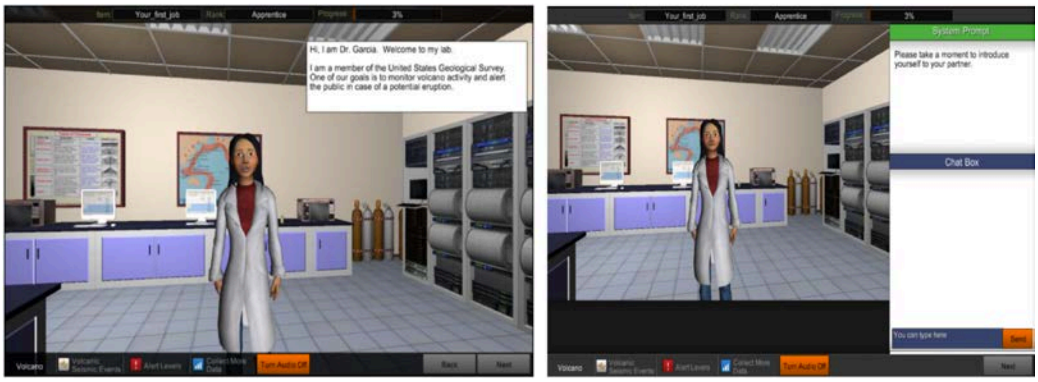

Figure 2. Single-user version (left) and collaborative version (right) of the simulation-based tasks.

We collected the data through Amazon Mechanical Turk, a crowdsourcing data collection platform (Kittur et al., 2008). We recruited 1,500 participants located in United States with at least one year of college education. We administered to them the general science test, personality survey, and demographic survey. Then we randomly selected 500 to complete the single-user version of the simulation. The remaining 1,000 were randomly paired into dyads to complete the collaborative version of the simulation. The data from the simulation task for each team included both the responses to the items in the simulation and the text chat communication between the team members around each item. There were seven multiple-choice-like items in the simulation task, and for each item, there were about five turns of conversation. Seventy-eight percent of the participants were White, 7% were Black or African American, 5% were Asian, 5% were Hispanic or Latino, and 5% were multiracial.

The responses to the multiple-choice-like items (seven such items) were scored based on the corresponding scoring rubrics as presented in Zapata-Rivera et al. (2014). In addition to scoring the outcome responses, we also annotated the chat communication during the collaboration based on our CPS framework (Liu et al., 2015). Two human raters were trained on the CPS framework, and they double-coded a subset of discourse data (15% of the data). The unit of analysis was each turn of a conversation, or each conversational utterance. The raters had two training sessions before they started independent coding. In the first session, the raters were trained on the 33 subcategories of the CPS framework using the skill definitions and coding examples for each subcategory. In the second training session, the trainer and two raters coded data from one dyad together to practice the application of specific codes and address issues specific to classifying utterances using the CPS framework. After the training sessions, the two raters independently coded the discourse data from 79 dyads. One of the 33 subcategories was assigned for each turn, and the inter-rater agreement in terms of unweighted kappa was 0.61 for all 33 subcategories.

Findings based on the aforementioned data and scores/annotations will be presented in the subsequent presentations.

Presentation 2: A CPS framework to support the assessment design and discourse analysis

Lei Liu, Jiangang Hao, Alina A. von Davier, and Patrick Kyllonen

Cognitive and social approaches to science learning have highlighted the importance of collaboration for helping students solve problems and achieve understanding. In educational assessment, there has been a strong recent interest in the evaluation of collaborative problem solving (CPS) as a both a cognitive and social skill (Griffin, Care, & McGaw, 2012; Liu, Hao, von Davier, & Kyllonen, 2015). In our research, we consider collaboration from a discursive perspective as collaboration often takes place in discursive settings (e.g., face-to-face conversations, forum discussion in learning management systems, and chat box in assessment). We define CPS as a process that includes both cognitive and social practices in which two or more peers interact with each other to share and negotiate ideas and prior experiences, jointly regulate and coordinate behaviors and learning activities, and apply social strategies to sustain the interpersonal exchanges to solve a shared problem. This definition describes CPS as both a cognitive and social process (Liu et al., 2015). The cognitive skills include individuals' ability of internalizing others' externalized cognition as well as developing one's own cognition during the problem solving process. The social skills involve individuals' skills of interacting with each other to develop and reach a shared group goal by externalizing one's cognition. In this presentation, we describe a CPS framework developed based on existing collaborative learning literature, the PISA 2015 CPS Framework (OECD, 2013), and ACTS21 CPS framework (Griffin et al., 2006). There are four major categories in the framework, namely, sharing, negotiating, regulating, and maintaining the communication (see Table 1). Under each major category, there are several subcategories to describe discursive features at the fine grain size (total of 33 subcategories). In addition, we present how we used the CPS framework to analyze dyadic discourse data and how different collaborative patterns emerged and were associated with group performance.

Table 1: CPS framework categories

	Description
Sharing	Conversations about how individual group members bring divergent ideas into a collaborative conversation.
Negotiating	Conversations about the team's collaborative knowledge building and construction through comparing alternative ideas and presenting evidence and rationale of an argument
Regulating	Conversations on clarifying goals, monitoring, evaluating, and confirming the team understanding during problem solving
Maintaining communication	Content irrelevant social communications

As described in Presentation 1, we collected data through a crowdsourcing approach and coded all chat data applying the CPS framework (unweighted kappa was 0.61 for exact match of codes based on 33 subcategories). To highlight collaborative discursive patterns, we introduce a "CPS profile" as a quantitative representation of the CPS skills of each dyad. The profile was defined by the frequency counts of each of the four CPS categories (e.g., sharing ideas, negotiating ideas, regulating problem solving, and maintaining communication). We used unigram and bigram models to represent the CPS profile. The unigram and bigram models are often used in natural language processing to represent text classifications. We adopted similar methods to represent the frequency counts of different CPS skills. We compared the CPS profiles of effective collaboration and ineffective collaboration and found that there were significant differences in the collaborative discourses. When using the unigram models, we found that in general, the effective collaborative teams tended to talk more and they particularly did more discussion to negotiate ideas (see Figure 3). When using the bigram models, we found that the effective teams tended to do more pairs of discussion with negotiations but the ineffective teams tended to do more pairs of discussion with sharing information only (see Figure 3). For example, the bigrams of Negotiate->Share and Negotiate->Negotiate occurred more frequently in effective groups than in ineffective groups. However, the bigram of Share->Share occurred more in the ineffective groups than in the effective groups.

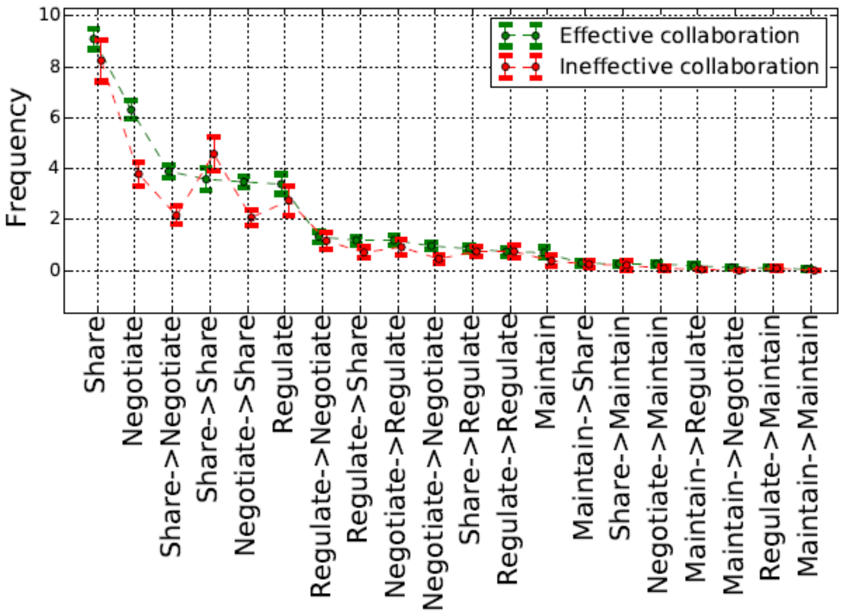

Figure 3. Unigram and bigram profile of CPS skills comparison. The error bars are the standard errors of the means.

Many theoretical and empirical analyses emphasize the importance of active participation and collaboration among students in promoting the effectiveness of online learning. However, there is a need of research to provide empirical evidence of more fine-grained patterns of collaboration that support the effectiveness of learning. Our study attempts to address such a gap. Our findings show that there were differences in dyads' CPS profiles associated with different outcomes of small group collaboration.

Presentation 3: A novel modeling approach for assessing CPS

Jessica J. Andrews, Deirdre Kerr, Robert J. Mislevy, Jiangang Hao, Lei Liu, and Alina A. von Davier

Simulation- and game-based tasks offer opportunities to capture novel sources of assessment data, as these environments afford the capturing of every action taken by students as they engage in game play (Owen, Ramirez, Salmon, & Halverson, 2014). Such affordances particularly lend themselves to capturing evidence of complex skills such as collaborative problem solving (CPS) that are often difficult to measure with more conventional items and tests. One major challenge, however, associated with the use of simulation- and game-based tasks for assessment purposes concerns making sense of the abundance of low-level data generated in these digital environments in order to make claims about individuals or groups. In this paper, we present a novel methodological approach that uses the Andersen/Rasch (A/R) multivariate IRT model (Andersen, 1973, 1995) as an innovative means of modeling interaction patterns. Interaction patterns characterize the ways in which groups interact using log data and performance outcomes. The A/R model addresses tendencies in observations that can be classified into a set of *m* exhaustive and mutually-exclusive nominal categories. In the current instantiation of the A/R model, we model propensities of dyads to behave according to a number of interaction pattern categories. Results from these analyses can be used to answer important questions in collaboration research. We demonstrate specifically how the approach can be used to explore gender and cultural differences in collaborative behavior and how interaction patterns relate to performance outcomes.

The chat logs for each dyad and the log files detailing participants' actions as they completed the ECSAP were coded for interaction patterns that were displayed. The seven items making up the first part of the task were separately coded for interaction patterns (Kappa = .83). That is, patterns were coded at the item level, as each dyad received an interaction pattern code for each of the seven items. Modified versions of Storch (2002) and Tan, Wigglesworth, & Storch (2010) models of dyadic interaction patterns were used to create a rubric for identifying the ways in which participants interacted with their partner. Specifically, the cooperative, collaborative, dominant/dominant, dominant/passive, and expert/novice interaction patterns were included in the rubric. An additional interaction pattern, fake collaboration, was added to the rubric to account for a recurring pattern of behavior not found in the models. Descriptions of each interaction pattern can be found in Table 2.

Table 2: Description of interaction patterns

	Interaction Pattern Description
Cooperative	Both participants share ideas relatively equally, but there is little engagement with the ideas that were shared
Collaborative	Both participants contribute relatively equally and jointly construct a response; engage with each other's ideas; provide explanations and evidence for contributions; critically evaluate other's contributions
Dominant/Dominant	Both participants contribute, but often outwardly seek to maintain own response; difficulty reaching consensus; disagreements
Dominant/Passive	Dominant member takes control of task and shows little effort in inviting contributions from passive member who maintains a passive role
Expert/Novice	One member with more content knowledge (expert) contributes more information, but also encourages contributions from less knowledgeable peer
Fake Collaboration	Both participants contribute information and seem to work together to reach consensus, but revised individual response choices show participants maintained their own (and different) responses

Four of the six interaction patterns (cooperative, collaborative, dominant/dominant, fake collaboration) were displayed as dyads completed the task. The dyad parameter estimates from the A/R model exhibited the propensities for dyads to display each of the coded interaction patterns. In exploring which interaction patterns dyads had the greatest propensity to display, 423 dyads (85.3%) had a tendency to display the cooperative interaction pattern, 62 dyads (12.5%) had a tendency toward the dominant/dominant interaction pattern, 8 dyads (1.6%) had a tendency to toward the collaborative interaction pattern, and 3 dyads (0.6%) had a tendency toward the fake collaboration interaction pattern when compared to all other patterns.

Dyad parameter estimates that corresponded to each of the four interaction patterns were correlated with dyad's team performance. Propensity toward the cooperative (r (494) =.28, $p < .001$) and collaborative (r (494) = .11, $p = .02$) interaction patterns were positively correlated with performance outcomes. Propensity toward the dominant/dominant interaction pattern was negatively correlated with performance outcomes (r (494) = -.21, $p < .001$).

The dyad parameter mean estimates corresponding to each interaction pattern were used to determine whether values were different across same- and mixed-gender and same- and mixed-race dyads. Results revealed no significant differences between same- and mixed-gender and same- and mixed-race dyads in their propensities to display each of the observed interaction patterns.

While there were no significant differences in how the subgroups interacted with each other, we did find differences in how the display of the different interaction patterns related to performance outcomes for the subgroups. For example, comparisons between correlation coefficients showed differences for male-male relative to female-female dyads ($Z = 2.57$, $p = .01$) and male-female dyads ($Z = -2.78$, $p = .01$) for the dominant/dominant interaction pattern. Specifically, the negative correlation between propensity toward the dominant/dominant pattern and performance outcomes was higher for male-male dyads relative to the other subgroups.

These results have important implications for assessment of collaboration, particularly with respect to concerns about fairness and ways of evaluating collaborative behavior. Modeling dyadic interaction patterns using the Andersen/Rasch model is a novel analytical approach for these kind of data and provide an output of a profile for each dyad showing their propensity to behave in accordance with a number of interaction patterns, each of which characterize elements of effective and poor collaborative behavior.

Presentation 4: Relations of individual general science knowledge and personality with collaborative performance

Mengxiao Zhu, Thales Ricarte, Jiangang Hao, Lei Liu, Alina A. von Davier, & Patrick Kyllonen

In collaborative problem solving (CPS), multiple individuals work collectively to solve the problems as a team. As suggested by studies in organization science, team performance can be influenced by many factors both at the individual level, such as individuals' content-related knowledge, and at the team level, such as the team leadership (Mathieu, Maynard, Rapp, & Gilson, 2008). In the assessment of collaborative skills, even though the environment is more confined than in the organizational settings, it is still unclear and remains a very interesting research question how individuals' knowledge/skills and personalities are related to their collective performance as a team. In this study, we focus on two individual level variables, individuals' general science knowledge and personality. The goal is to examine the relationship between these two variables and the individuals' collaborative performance in the task.

This study used the data collected using the ECSAP system introduced in the presentation one of this symposium. Participants' general science knowledge was assessed using a 37-item general science test. To measure individuals' personality, we adopted the Big Five personality traits (McCrae & Costa, 1999). For data collection, to reduce the burden of the participants and at the same time maintain the reliability of the measure, we used the TIPI (Gosling et al., 2003), which contains only ten items and was proven to be a reliable measures of the Big Five personality traits. The analysis included the general science knowledge scores, personality trait measures, as well as scores on the seven items in the simulation-based tasks. For the collaborative version of the simulation task, individuals first worked on the tasks and submitted their individual answers, had a team discussion, and then had the opportunity to revise their final answers. We recorded scores on both the initial scores and the final scores. In many cases, the final scores were better than the individual scores prior to discussion, but there were also cases in which the final scores were lower than the individual scores before discussion.

The reliability of the general science knowledge test is very good, as shown by Cronbach $\alpha = 0.89$ for the 37 general science items. We further categorized the individuals into the low performing and high performing groups using the sample median of 28 as the cutoff value. Individuals who got scores of 28 and lower were considered as having low general science knowledge (L), and those who got scores higher than 28 were considered as having high general science knowledge (H). For each team, three combinations of individuals were possible, LL, LH and HH. We then compared the performance of these three different types of teams in the CPS tasks. The results showed that, not surprisingly, the HH teams preformed the best for both the initial scores and the final scores, followed by the HL teams and then the LL teams. We also compared the differences between the average initial scores of the two team members and the average final scores to check whether or not different combinations of team members differ in terms of score changes. All three types of teams had positive score increases between the initial scores and the final scores. However, there were no differences in the amount of increase among these different types of teams.

We were also interested in how individuals' general science knowledge would affect their gains from the collaboration. Since each individual can be H or L on general science knowledge, from the individual perspective, there are four types of scenarios, L working with L, L working with H, H working with L, and H working with H. The analysis at the individual level (as shown in Figure 4) showed that everyone benefited from the collaboration regardless of whether it was collaboration of L with H, or H with L, or individuals with equivalent general science skill levels. Among all the possible scenarios, individuals with low general science knowledge benefited the most from the collaboration when working with individuals with high general science knowledge.

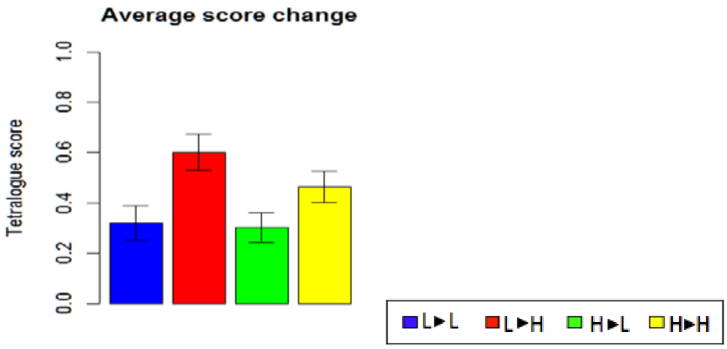

Figure 4. Comparisons among the individuals in terms of the improvement after collaboration. The error bars are the standard errors of the means.

For the personality surveys, since each individual reported on all five personality traits on two items with the 1 to 5 Likert scale, the numbers of teams with different combinations of personality traits are too big, which made it impossible to conduct a similar analysis as in the analysis for the general science skills. Instead, we categorized the teams into three categories based on the collaboration outcomes. During the collaborative process, two team members first submitted their initial answers, and they resubmitted after team discussion. During this process, individuals may or may not change their initial answers, and their scores may also increase, decrease, or stay the same. Based on the individual behaviors and the outcome of the behaviors, we categorized the teams into three groups: Group 0 made no changes and had no score changes; Group 1 made changes and the scores decreased; Group 2 include the teams who made either beneficial changes or harmless changes, that is made changes and scores either increased or stayed the same. We then compared the Big Five personality traits for the three groups. We ran ANOVA analyses and compared the average personality levels for all five dimensions, as well as the absolute difference between the two team members for all five dimensions. The only significant difference, $F(2,\ 382) = 6.23,\ p = 0.002$, was observed for agreeableness, which has characteristics of trust, cooperation, and kindness. Post hoc Tukey tests showed that Group 1 had significantly higher values than Group 0 with a difference of 0.34, and $p = 0.007$; Group 1 also had significantly higher values than Group 2 with a difference of 0.37, and $p = 0.001$. The difference between Group 2 and Group 0 was not significant. These results indicate that high agreeableness was associated with low collaborative performance.

With interesting findings separately on the relations of general science knowledge and personality with collaborative performance, we plan to integrate the studies on these two dimensions and explore the interaction between general science knowledge and personality. During the collaborative processes, we also coded the conversations between the participants, which provide another measure on their collaborative skills. Thus, future work will also examine how the measure of collaborative skills relates to general science knowledge and personality.

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Scripted and Unscripted Aspects of Creative Work With Knowledge

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Abstract: Advances in scripting theory and advances in support for student-driven knowledge construction call for a reconsideration of long-standing issues of guidance, control, and agency. This symposium undertakes a fresh analysis based on the relations between two widely adopted approaches that may be poles apart but arguably viewed as variations within a common applied epistemological framework. The two approaches are scripted collaboration and Knowledge Building. Rather than focusing on similarities and differences, the symposium will address deeper problems such as reconciling external supports of all kinds with the self-organizing character of knowledge construction and integrating such supports into classrooms viewed as knowledge-creating communities. The centerpiece of the symposium is a panel discussion that includes experts who provide different theoretical viewpoints. In its synthesis the symposium will capture and make sense of what is strongest in the two approaches and provide a broad conceptual basis for next-generation initiatives.

Introduction

In their original formulation of the idea of scripts, Schank and Abelson (1977) defined them as recurrent, conventional, predictable, and relatively fixed patterns of behavior. Early educational applications of scripts stayed close to this conception, emphasizing roles and prescribed behavior associated with those roles (O'Donnell, Dansereau, & Rocklin, 1987). The prescriptive nature of such scripting seemed to put it at odds with constructivist educational approaches that place a premium on student epistemic agency, exploration, and explanation or theory building. In more recent developments, however, concepts of scripts and scripting have broadened to encompass much of what more open educational approaches espouse. In one formulation, "internal collaboration scripts" are taken to include small, reusable pieces of procedural knowledge that can be assembled into novel wholes (Fischer, Kollar, Stegmann, & Wecker, 2013). However, "external collaboration scripts," as used in a variety of applications, continue to have a prescriptive character (King, 2007), although recent work advocates flexible (Dillenbourg & Tchounikine, 2007) and adaptive external scripts (Adamson et al., 2014; Diziol et al., 2010) that seem to resemble much more the notion of scaffolding. Clearly, the relation between scripting, scaffolding, and knowledge construction needs to be examined anew. The self-organizing character of thought and action scarcely entered the discourse of 30 years ago, but it is now a fundamental conception. At the same time, refinements in ways of supporting collaborative knowledge construction and problem solving have cast doubt on the old antinomies regarding structure and agency.

The purpose of this symposium is to have a constructive discussion focused on two educational approaches that from some standpoints are poles apart but that from another viewpoint represent potentially compatible variations within a common applied epistemological framework. The two approaches are scripting, as represented in the "Script Theory of Guidance" (Fischer et al., 2013), and Knowledge Building, as represented in "Knowledge Building: Theory, Pedagogy, and Technology" (Scardamalia & Bereiter, 2014). At a minimum the symposium should develop a new map of the conceptual field taking into account recent conceptual developments in both areas, providing a firmer conceptual foundation for future research. Hopefully the symposium will go beyond this in the direction of an integrative framework to resolve long-standing differences.

Plan of the symposium

The plan of the symposium is to devote the first 25 minutes to introductory comment and two presentations setting forth views on the support of collaborative knowledge construction from the respective standpoints of script theory and knowledge building theory. Following this will be a moderated panel discussion in which the two presenters will be joined by three other participants for a back-and-forth aimed at building upon or resolving issues raised in the initial presentations. The moderator will determine the point at which to open the discussion to the audience, but an expected minimum of 20 minutes will be available for audience participation.

Initial presentations

Frank Fischer and Freydis Vogel

In our presentation from the standpoint of script theory we introduce the development of the understanding of (internal) scripts as rather rigid cognitive structures to the dynamic reconfiguration of its smaller components and how scaffolding or external scripts can be created to support learners regarding the use and development of their internal scripts. The introduction is arranged in four parts that represent the different notions of script theory and its current developments.

In the first part of the presentation, we sketch our view on the development of the script concept from a relatively rigid cognitive structure resulting from repeated encounters with identical and highly similar situations to the current view of scripts as flexibly adaptive support for groups targeted at activating existing internal (cognitive) script components (Schank, 1999; Schank & Abelson, 1977).

In the second part we present a summary of one theoretical model that uses this more recent notion of scripts and scripting, namely the Script Theory of Guidance for computer-supported collaborative learning (SToG, Fischer et al., 2013). With four types of components of internal and external scripts (play, scene, role, and scriptlet) and seven principles, this theory aims at explaining how CSCL practices are shaped by dynamically re-configured internal collaboration script components. It gives answers to the question how internal collaboration scripts develop through participation in CSCL practices. It tries to conceptually link the role of subject matter knowledge and knowledge on collaboration. The theory also suggests that transactive forms of knowledge application will better facilitate learning than non-transactive forms. Further, the theory explains how external collaboration scripts modify CSCL practices and how they influence the development of internal collaboration scripts. The principles specify an optimal scaffolding level for external collaboration scripts and allow for the formulation of hypotheses about the fading of external collaboration scripts. We will report empirical results partly in support of the model, partly challenging some of the principles (Vogel et al., 2016).

In the third part we will apply SToG to explain some phenomena of collaborative knowledge construction. For example, there is a series of experimental studies on facilitating competences of mathematical argumentation. These studies indicate that external collaboration scripts that facilitate transactive argumentation in the process of collaboration have positive effects on social-discursive aspects of the mathematical argumentation skills of the individuals involved (Vogel, Wecker, Kollar, & Fischer, in press). Transactive arguments are arguments that contain ideas that (a) go beyond what is given in the learning environment and (b) build on arguments of the learning partners. This finding can be seen as evidence for the claims that externally scripted environments can indeed facilitate creative and substantive processes and that the stimulated processes are causally related to improved mathematical argumentation skills.

SToG enables predictions with respect to the necessary level of scaffolding for learners with different internal collaboration scripts. The SToG would predict positive effects of even micro-managing the composition of a contribution if it turned out that students cannot access reasonably suitable internal scriptlet components. Furthermore, SToG would predict that removing the few existing scaffolds that are given in Knowledge Building are beneficial for advanced learners. Advanced learners dispose of the respective self-regulation capabilities or in other words, the necessary internal collaboration script components.

In a final part we will address the aspect of flexibility through adaptivity and adaptability of external collaboration scripts and put forward the argument that this flexibility is a defining feature of scaffolding (Dillenbourg & Tchounikine, 2007). Adaptivity refers to the technology diagnosing and adjusting the scaffolding level automatically (e.g. Diziol, Walker, Rummel, & Koedinger, 2010). Adaptability, in contrast, means that the external script can be changed by the learners using it. Both adaptivity and adaptability of external scripts seem to be promising ways to improve learning. While adaptivity needs automatic analysis of learning data in real-time (e.g. Mu, Stegmann, Mayfield, Rosé, & Fischer, 2012; Rosé et al. 2008), the adaptability needs less resources and lets students learn in a more self-regulated way. All means of implementing flexibility to external scripts have the goal to adapt the amount of scripting to the learners' needs that are related to the development of their internal scripts. Regarding the SToG perspective notion of creating external guidance that is perfectly adapted to the learners' internal scripts, Knowledge Building is in part "under-scripted", meaning that too little external guidance is provided for beginning learners who do not yet have access to productive internal script components because the CSCL activity of Knowledge Building is radically new for many of them. In other parts, Knowledge Building is possibly sometimes "over-scripted" when scaffolding like semantic pointers remain although they are no longer needed. Thus, we will raise the question to what extent flexibly adaptive and adaptable scaffolding could strengthen Knowledge Building. In the first part of the presentation, we sketch our view on the development of the script concept from a relatively rigid cognitive structure resulting from repeated encounters with highly similar situations to the current view of external collaboration scripts as flexibly adaptive group supports facilitating the configuration and re-configuration of networks of existing internal script components.

Carl Bereiter and Marlene Scardamalia

Knowledge Building is a principles-based rather than a procedures-based approach to knowledge construction (Hong & Sullivan, 2007). The need for pedagogical and technological supports for novice knowledge builders is recognized, but care is taken not to undermine such principles as epistemic agency, pervasive knowledge building, collective responsibility for idea improvement, and identification with the worldwide knowledge-creating community (Scardamalia, 2002; Bereiter & Scardamalia, 2014). This means maximizing the intelligence operative among the students in proportion to the intelligence contributed by the teacher and the teacher's tools (of which external scripting would be one kind of tool). The most script-like elements of Knowledge Building technology are what we call "epistemic markers," but which are commonly called "scaffolds," a term also common in the scripting literature. A typical set of markers for theory building includes "My theory," "I need to understand," "A better theory," and "This theory does not explain." Unlike other approaches that use such supports, in Knowledge Building their use is not obligatory and there is no fixed order. Thereby hangs an anecdote that casts an interesting light on the question of whether epistemic markers are a form of scripts. The children in one primary grade class decided they didn't need so many markers, so they reduced them to two—"My theory" and "Did you know"—and these appeared to be working very well. However, the teacher had introduced the students to the distinction between "knowledge telling" and "knowledge transforming" (Scardamalia, Bereiter, & Steinbach, 1984), "knowledge telling" being a composing strategy that outputs topically relevant information without the processing that would have any transforming effect on the writer's personal knowledge. One student remarked that what he and classmates were doing in response to the "Did you know" scaffold was knowledge telling. The others agreed and they proceeded to restore the epistemic markers that signaled a more serious effort at theory building. If this is to be called scripting, then we need to consider the possibility of students scripting their own collaborative behavior and that this sort of action could be an important step toward full competence in collaborative knowledge building. Despite their being optional, students use them, partly because the technology provides an easy way to insert them in text, just by clicking on the item. In this sense they are more like having a personal scribe than a script, and they remain useful, becoming part of the vocabulary students use in their collaborative work, whether online or in oral conversation. They can be revised or turned off by the teacher or students as a collective decision. The epistemic markers, however, are only one element in an epistemically rich environment that Knowledge Building teachers have been able to foster—even in kindergarten, where there is no Knowledge Forum and no epistemic markers. Other important elements of an epistemically rich environment are knowledge-building concepts such as building on, rising above, explaining, and idea improvement. Young students initially understand these in very limited ways, but gradually, through their own knowledge building efforts and with help from their teachers and peers, the concepts take on fuller meaning and become not just supports for action but part of how they see the world, part of their culture. Consistent with this expectation, a comparative experiment showed that students engaged in Knowledge Building gain better understanding of the nature of science than students pursuing more guided inquiry (Chuy, et al., 2010).

Knowledge Building, like knowledge creation in general, achieves its objectives mainly through what is coming to be called "design thinking," a generalization of the kind of thinking that goes on in creative design groups such as Ideo (Brown, 2009). This is in contrast to what may be called analytical/evaluative thinking (Martin, 2009), which has been the prevailing form of thought in formal education since ancient times. Analytical/evaluative thinking has a role to play in knowledge advancement, but it does not generally produce new knowledge—theories, inventions, problem solutions, and the like. Its main function is assessing the validity of knowledge claims.

Analytical/evaluative thinking is eminently scriptable, as witness the abundant work on scripting argumentation (Andriessen, Baker, & Suthers, 2003). One can find on the Web efforts to script design thinking, but they are not very impressive. Design thinking is a self-organizing process par excellence (with explanation building or theory building as one type of it especially relevant in education). Its products are emergents, not predictable from their constituent elements. If we are serious about students being genuine creators of knowledge and not just play-acting the roles of scientists and other knowledge creators, then the education system must find ways to support design thinking—not only in the arts and engineering, where design thinking more or less comes with the territory, but also in core work with the "big ideas" of the disciplines. This is a new challenge for educators—a distinctly 21st century challenge. There are no doubt teachable elements, which may be treated as reusable components of internal scripts. But when it comes to external scripting, there is a danger that the kinds of scripts that work for argumentative evaluation of knowledge claims will be heedlessly applied to design thinking, with potentially stultifying effects. One type of support for Knowledge Building that is currently under active development and showing great promise is feedback tools students themselves can use to assess progress at the group level and to identify shortcomings—for instance a domain vocabulary tool that allows students to compare the vocabulary used in their discussion with the vocabulary used by experts discussing the same topic and another tool that graphs frequency of use of the various epistemic markers (Resendes, Scardamalia, Bereiter, Chen, & Halewood, 2015). These supports are obviously not scripts, although the use students make of them is potentially scriptable. But is that necessary or desirable?

The crucial role of the teacher in Knowledge Building is community development. All teachers devote effort to community development and are often very effective at it. The particular challenge, however, is building a community organized around the collective development of community knowledge. This is something beyond organizing for collaborative pursuit of individual learning goals. It is comparable to the effort of progressive disciplines of all sorts to advance the state of knowledge in their domains. Experienced Knowledge Building teachers tell us that it can take upwards of half a year to build such a community from scratch, but that it is worth the effort because once it is achieved the community has its own dynamic of advancing knowledge frontiers and the teacher does not have to work constantly to make it happen; benefits are exponential if the teacher does not need to start from scratch each year. But are we talking about students internalizing a knowledge-creating script? This is an interesting question to explore, but we sense that scripts are not the most informative way to look at what goes on. Concepts such as ethos, values, self-identity, and community-level goals seem to get closer to the heart of the educational challenge.

We suggest that the relation between Knowledge Building and scripting be thought of as consisting of two diverging paths of support for students' thinking. At the lowest level of support, common to both paths, are what may be described most simply as reminders—epitomized by IBM's famous motto, "THINK," and Apple's more recent "think different." It is assumed that users already understand and appreciate these injunctions but can benefit from being reminded of them. One path of increasing support leads in the direction of algorithms, that is to say rule-based systems, as epitomized in John Anderson's (1993) *Rules of the Mind.* Various levels of scripting may be found along this path, though generally stopping short of full embodiment of a production system. The other path leads in the direction of self-organizing group knowledge-creating processes fostered through support for increasingly complex forms of interaction and feedback, including for example visualizations of epistemic markers used in the discourse and multiple visualizations to help participants criss-crossing the landscape of their ideas (Scardamalia & Bereiter. 2016).

Panel discussion participants

The moderator will steer the participants toward highly interactive discussion related to ideas and issues raised in the presentations and away from separate presentation of prepared remarks. Participants are:

Ulrike Cress (moderator). Since 2008 Ulrike Cress is Professor of the University Tuebingen and since 2017 she is also Director of the Leibniz-Institut für Wissensmedien (Knowledge Media Research Center) in Tuebingen. She works on mass collaboration and knowledge creation with social media. In her work (Cress & Kimmerle, 2008, 2017) she aims to combine different methodological approaches (experiments; big data studies; discourse analysis) and she links different theoretical perspectives (information-processing perspective, socio-cultural perspective). This makes her a boundary spanner between the different poles the symposion deals with.

Carl Bereiter is one of the originators of Knowledge Building as an educational approach and has been active in research related to it and to supportive technology design. His particular interest has been in the epistemological aspects of knowledge production (Bereiter, 2002, 2014, 2016).

Frank Fischer co-developed the Script Theory of Guidance for CSCL (Fischer et al., 2013; Stegmann et al., 2016) and has been involved in experimental field and laboratory studies on collaborative learning with a focus on facilitating scientific reasoning and argumentation. In collaboration with Carolyn Rosé he has also explored ways to automatically analyse argumentation (Rosé et al., 2008; Mu et al., 2012) to enable flexible scripting.

Kai Hakkarainen has studied technology-mediated learning more than two decades. He has developed a knowledge-creating learning framework that integrates knowledge building and activity theory (Paavola & Hakkarainen, 2014; Paavola, Lipponen, & Hakkarainen, 2004). His work on "knowledge practice" deals with relations between knowledge building and social practices (Hakkarainen, 2009).

Marlene Scardamalia invented CSILE, the first networked collaborative learning environment and is active in all aspects of research on Knowledge Building and Knowledge Building technology. As holder of the Presidents' Chair in Learning and Knowledge Technology at the University of Toronto, she has led an international network of researchers and innovators in education devoted to extending the limits of the possible in students' functioning as knowledge-creating communities.

Freydis Vogel, in her research, is concerned with scripts for computer-supported learning since 2009 and conducted a series of studies about argumentation scripts in the context of mathematics (Kollar et al. 2014, Vogel et al. 2016). She also co-authored the first meta-analysis about computer-supported collaboration scripts (Vogel, Wecker, Kollar, & Fischer, 2016). Her future research plans are to follow the question how learning with scripts can be designed in a way that it supports and demands more self-regulated learning.

The moderator will determine when to open the discussion to audience participation, based on progress being made in the panel discussion and on signs of audience interest. It is assumed that the topic of the symposium and the contrasting positions will generate enough audience interest that it will not be necessary to pose issues for discussion.

Key issues

The following are issues raised in the prepared presentations that are expected to be further developed through the panel discussion and audience input:

- Does script theory encompass all forms of external support for knowledge construction? If not, what are unscripted supports?
- If knowledge construction is a self-organizing process at both individual cognitive and at collaborative group levels, what implications does this have for the design of external supports and supportive environments? What kinds of flexible/open structuring can provide needed support for engaging students in authentic scientific inquiries and design practices while maintaining openness to emergence?
- Is it realistic to empower students to collectively design their own scripts or other forms of support?
- Is the production of public or community knowledge (the kind of thing mature research teams do) a viable objective for the school curriculum? If so, how does it fit with objectives framed in terms of individual knowledge and skills?
- In the development of community ethos, norms, and identity, what are potentially scriptable and unscriptable aspects?
- What is the place in collaborative knowledge construction of group level assessment (of discussion quality, for instance, or the state of intellectual and disciplinary norms) as distinct from assessment at the individual level? Does this have implications for the use of more prescriptive forms of support?
- To the extent that there is a fundamental difference between the approaches discussed in this symposium, what does this mean for educational policy? In particular, what does it mean for the popular belief that a more highly structured or guided approach is needed for certain types of students while others may profit from a less regulated approach?

Significance of the symposium for the CSCL community and the CSCL 2017 theme

In recent years both scripting and Knowledge Building have had a substantial presence in CSCL and ISLS meetings and publications. Both, moreover, have enjoyed an expanding influence in educational practice. They have, however, tended to occupy separate universes, with their own vocabularies and knowledge claims. Their differences could be matter for a lively debate. However, on the basis of informal discussion, the applicants have felt that there is enough common ground to justify a symposium focusing our diverse views on issues that underlie all efforts to promote collaborative knowledge construction. The issues briefly itemized in this proposal are ones that go to the heart of what CSCL and collaborative knowledge construction are about. The issues are also relevant at a deep level to the conference theme of "prioritizing equity and access." It would be easy to conclude, and many educators may already have concluded, that scripting is best for the academically less prepared students and Knowledge Building is appropriate for the more advanced. This would be an unfortunate resolution from the standpoints of both approaches. To go beyond such over-simplification, to provide an education that is accessible to all yet does not exclude some students from the opportunity to become full members of a knowledge society, a convincing and realistic resolution is need of the issues that are the focus of this symposium.

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Posters

Does Collaboratively Constructing Contrasting-Case Animations Facilitate Learning?

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Abstract: Work-in-progress is presented to investigate the learning outcomes facilitated by collaboratively constructing pairs of contrasting-case animated skits based on concepts covered in an undergraduate psychology course. Contrasting cases are instructional materials designed to help students notice characteristics that they might otherwise overlook by providing an example that demonstrates a concept and a secondary example that demonstrates an opposing concept. A quasi-experimental design will compare two groups of students to assess the effectiveness of this approach.

Research advances in the learning sciences suggest that educators can improve learning outcomes by improving teaching practices. In higher education, the traditional pedagogical model first asks students to read textbook chapters followed by classroom lectures. Instructors then assess learning via exams, presentations, or papers. The traditional approach certainly provides evidence of learning but the limits of the learning become apparent when students are challenged to transfer the knowledge they learn to different contexts. Problem-based learning (PBL) approaches better address the issue of transfer. Instead of starting with reading and lectures, students first encounter a real problem to solve which demands application of new knowledge.

One of the risks of problem-based learning is that engagement is mistaken for learning. In a small-group discussion, learners may all enthusiastically participate, but assessments of learning often reveal disappointing results. To move beyond just discussing new knowledge, many PBL models ask students to create an artifact. While the media of the artifact may differ, it should provide the learner with a way to express the solution to the specified problem that makes their thinking visible. Students can also share learning artifacts as students don't have many opportunities to learn from the more complex efforts of their peers.

Contrasting cases are instructional materials designed to help students notice distinctive characteristics that they might otherwise overlook by providing an example that demonstrates a concept and a secondary example that demonstrates an opposing concept. (Schwartz Chase, Oppezzo, & Chin, 2011). Contrasting cases can make new properties and features of a given concept explicit so that even novice learners will not miss them (Schwartz et al. 2011). This approach originated in theories of perceptual learning that emphasized people's ability to differentiate knowledge they acquire (Bransford, Franks, Vye, & Sherwood, 1989; Gibson 1969). The overall goal of using contrasting cases is to highlight similarities and differences along a common dimension and help people notice specific dimensions that make the concepts distinctive. This kind of instructional support should be particularly important to struggling writers since they usually have difficulties identifying limitations of their own writing.

Although studies that empirically tested the effects of contrasting case-based instruction on self-assessment of writing are scarce, a number of studies have documented benefits of having students analyze and discuss contrasting examples when learning new subject matter (Gentner, Anggoro, & Klibanoff, 2011). For example, contrasting case-based instruction improved school age children's learning mathematical concepts (Hattikudur and Alibali 2010); children's acquisition of verbal meaning (Childers and Paik 2009); physics (VanLehn and Van De Sande 2009); and college students' business analysis abilities (Gentner, Loewenstein, & Thompson, 2003).

Many researchers noted the importance of presenting the contrasting examples side by side in order to notice relevant distinctions. Gentner et al. (2003), for instance, advocated that analyzing contrasting cases concurrently, rather than one at a time, was key to producing benefits. This was because when cases were examined one at a time, students tended to focus on surface features, had more difficulties in retrieving what was learned, and were less likely to notice important differences between the cases. For example, college students who compared two business cases by reflecting on their similarities and differences concurrently generated higher quality business solution strategies than those students who read and reflected on the same set of contrasting cases sequentially (Gentner et al. 2003).

Research focusing specifically on how students learn from artifacts finds that pairs of artifacts demonstrating contrasting cases enhances learning outcomes (Lin-Siegler, Shaenfield, & Elder, 2015). Specifically, Lin-Siegler, et al. (2015) found that providing students with good and poor examples of written compositions lead to better learning outcomes compared to students receiving two well-written examples.

Based on these ideas, the present research *in progress* investigates the collaborative use of a simple web-based animation authoring tool for students to create pairs of contrasting case skits. For example, a skit demonstrating the authoritative parenting style may enhance student understanding of that style, but more effective learning about parenting styles would stem from creating a pair of videos – one demonstrating the authoritative parenting style and one demonstrating a contrasting style (the authoritarian, style, for example). Pairs of contrasting artifacts help learners understand the important differences between concepts which one artifact alone can't.

Methods

To assess the effectiveness of this approach a quasi-experimental design will compare two sections of an undergraduate Adolescent Development course. During each week of the 15-week course, students will work in dyads to create a pair of animated skits in response to a problem-based scenario (two examples: 1. *How should parents negotiate a cell phone usage contract with adolescents*? 2. *How can we use restorative justice principles to structure conflict resolution*?). The students in the contrasting-case group will create two skits. One skit showing a developmentally appropriate response to the problem-based scenario and a second skit demonstrating a developmentally inappropriate response. Students in the control group will create two skits showing developmentally appropriate responses. Students will use GoAnimate for Schools, a web-based animation authoring environment, to produce the skits (https://goanimate4schools.com/). Students first choose a background and characters. Then they just type the dialogue and the video is ready to view (Figure 1 provides a screen capture of an example skit).

Students take a weekly 15 item quiz measuring conceptual and applied knowledge. The mean of each student's scores will provide a measure of individual learning. In addition, the discussions between students in three dyads in each condition will be audio recorded to provide case studies to illustrate the differences in the planning discussions. At the time of proposal submission, no results are currently available. The data will be analyzed after the data collection ends in the middle of May 2017.

Figure 1. Screen capture of video skit produced in GoAnimate for Schools.

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Socio-Semantic Network Analysis of ijCSCL Articles: Development of CSCL Ideas in ISLS

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Abstract: Although most computer-supported collaborative learning (CSCL) reviews apply qualitative approaches, computational approaches are increasingly common. In this study, we propose socio-semantic network analysis. We use words from article abstracts as nodes and co-occurrence as edges to create socio-semantic networks over ten years of International Journal of Computer-Supported Collaborative Learning publications. We find that authors have emphasized the cognitive level of learning with interactive, representational, and guiding pedagogical measures in the CSCL research framework.

Background and purpose

Computer-supported collaborative learning (CSCL) is a representative study field in the International Society of the Learning Sciences. Reviews of CSCL studies generally take one of two approaches. One is the qualitative approach driven by theoretical orientations. Stahl et al. (2006) and Suthers (2006) discussed core ideas in the field and suggested directions for the first publishing year of the International Journal of Computer-Supported Collaborative Learning (ijCSCL). In their review, Stahl et al. summarized the focus of CSCL as learning through student collaboration with other learners, in contrast to traditional knowledge transmission models. They moreover suggested new theories, methodologies, and technologies for integration to further support effective classroom collaboration. Suthers further emphasized inter-subjective epistemologies of collaborative learning as a promising theoretical orientation to examine how learners could perceive technological affordance in CSCL contexts. A recent work by Kirchner and Erkens (2013) introduced a CSCL research framework focusing on the level of learning (cognitive, social, or motivational), unit of learning (individual, group, or community) and pedagogical measures (interactive, representational, or guiding). Using this framework, they demonstrated how previous studies could be classified in a 3 × 3 × 3 cube.

A more recently introduced approach is data-driven computational or quantitative methods. Tang et al. (2014) retrieved from Web of Science 1,438 papers published between 2006 and 2013 and conducted document co-citation analysis, exploratory factor analysis, and social network analysis of 403 documents. They identified six subfields in CSCL: (1) representation, discourse, and pattern, (2) factors influencing CSCL, (3) intervention and comparison, (4) critical reasoning, (5) process of social construction, and (6) design and modeling of CSCL. Furthermore, they found several pivotal documents playing a boundary-spanning role.

Both these approaches are valuable for systematic reviews. However, these endeavors have developed in parallel, but not in an integrated way. Further research is needed to consider how the qualitative and computational approaches can complementarily investigate development in the field. In this study, we propose socio-semantic network analysis (SSNA) as a new methodological perspective. In SSNA, researchers use matrices of words within paragraphs or sentences as data (Schaffer et al., 2009; Oshima et al., 2012) rather than social actions like citations or comments. Links between word nodes are created by calculating word co-occurrence frequencies within units of analysis. The socio-semantic network of vocabulary and its structural change can reveal how ideas develop through participant interactions. This approach is adopted in recent CSCL studies to analyze student roles in collaboration and to detect productive interaction patterns (e.g., Ma et al., 2016).

We conducted SSNA on articles published in ijCSCL from 2006 to 2015 to examine how CSCL ideas have developed in the Society of the Learning Sciences and to suggest future directions. Our dataset is small in comparison with previous computational research, but it focuses on idea development in our society, since the ijCSCL is the flagship journal of CSCL community in the International Society of the Learning Sciences. Furthermore, we focus on ideas developed in ijCSCL publications over time rather than how articles are connected by citations. This new approach is expected to provide insights not found in previous computational research.

Procedure of SSNA

There were 239 articles published in the journal from 2006 to 2015. We collected article information from the journal website and used abstracts as SNNA data. To create word matrices as datasets, we first calculated the term frequency–inverse document frequency (tf-idf) value of each word within abstracts in ten years, then selected the fifty highly ranked words. Also, we again calculated the tf-idf value of each word within abstracts in each year, then selected thirty highly ranked words. After our selection process, 295 words were used as the SNNA dataset, which was processed using Gephi (https://gephi.org/).

Results and discussion

Development of Ideas in ijCSCL over ten years

We created a socio-semantic network for each year. We detected edges whose pointwise mutual information (PMI) exceeded 2.0 for visualization (Fig. 1). The structure of the resulting socio-semantic networks was found to develop from a cluster with a single core word (e.g., "portfolio" in 2006) to more diverse networks of ideas mediated by several core words over time (e.g., "community," "engagement," "modules," and "L2L2" in 2015).

Words appearing in more than five years were "inquiry," "engagement," "object," "network," "meaning," "source," "dialogue," "dyad," "argumentation," "awareness," and "script," suggesting application of these terms to further understanding in the field. Furthermore, words such as "inquiry," "network," "argumentation," and "script" were boundary spanners across studies over the years. The SSNA results suggest that authors mostly focused on the cognitive level of learning with interactive, representational, and guiding pedagogical measures in the CSCL research framework (Kirschner & Erkens, 2013). Future research will address social and emotional levels of learning to aggregate our findings in the CSCL research framework.

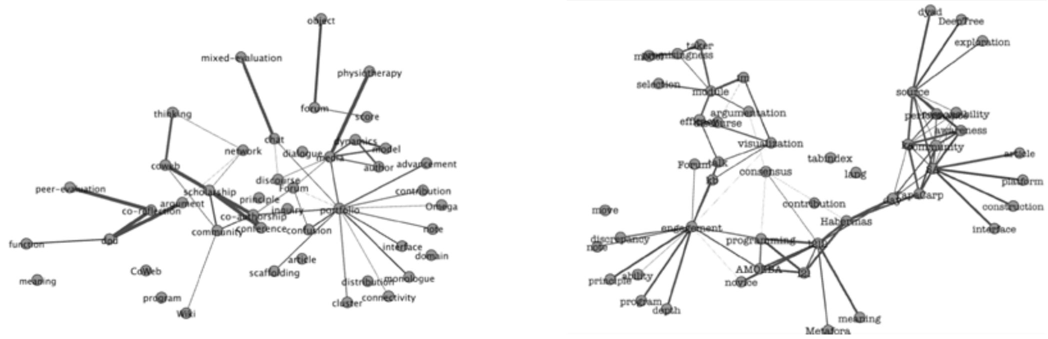

Figure 1. Structural Change in Socio-Semantic Networks of Words in ijCSCL (left: 2006, right: 2015).

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Students’ Engagement in a Science Classroom: Does Cognitive Diversity Matter?

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Abstract: The purpose of the study was to investigate whether cognitive diversity would impact students’ engagement in small-group learning in a K-12 science classroom setting. A total of 45 seventh-grade students were recruited to participate in the study where two conditions were compared: homogeneous groups (all low-ability students) vs. heterogeneous groups (low-ability students with one high-ability student). Participating students were randomly assigned into six homogeneous groups (24 individuals in total) and five heterogeneous groups (21 individuals in total). The results revealed that the heterogeneous groups had significantly higher behavioral, emotional, social and cognitive engagement than the homogeneous groups.

Introduction

Advocates of cognitive diversity argue that learners with different levels of knowledge and skills could create a large shared group knowledge base or skill base. As a result, each group member could draw on that shared base, which resulted in fostered learning and performance. Also, in a heterogeneous group, high-ability learners need to restructure their knowledge in order to assist low-ability learners to learn and understand, a process which may benefit both parties (Webb, Nemer, & Zuniga, 2002). It is also possible that cognitive diversity is not as effective as expected in terms of impacting learning. Individuals with different levels of knowledge and skills may encounter conflicts and difficulty in communication, which negatively impacts group cohesion and member’s satisfaction (Curseu et al., 2007; van Knippenberg & Schippers, 2007). Therefore, the negative impacts of cognitive diversity within groups could attenuate the effectiveness of small-group learning (Curseu & Pluut, 2013). Therefore, it is necessary for researchers to examine how individuals are engaged in small-group learning. The purpose of the study was to investigate whether cognitive diversity would impact students’ engagement in small-group learning in a K-12 science classroom setting.

Method

Participants and design

A total of 45 junior high school students (24 females) were recruited to participate in the study. Their average age was 12.42 years old (standard deviation = .62 years old) with a range from 11 to 14 years old. All of them were seventh-grade students from a key junior high school in Shanghai, China, and were all enrolled in a science course as their electives. They did not receive any monetary or physical reward for participating in the study.

This study used a one-way between-subjects design with two conditions (homogeneous group vs. heterogonous group). Participating students were randomly assigned into six homogeneous groups (24 individuals in total) and five heterogonous groups (21 individuals in total). Each heterogonous group only had one high-ability student and all students within a homogeneous group were low-ability students. Except that one heterogeneous groups had five individuals, all the remaining ten groups had four individuals each group.

Implementation and procedures

The study was implemented in a regular 90-minute face-to-face class session in a junior high school in Shanghai. Based on students’ performance in the prior course projects, the teacher selected the top five students in that class and identified them as five high-ability students. Each of these five students was randomly assigned to a seat in class when they came to the class. The rest of the students were then randomly assigned to the remaining seats in the classroom.

Measures and instruments

Behavioral, emotional and social engagement was assessed by three scales that were adapted from the previous research (Van Damme, De Fraine, Van Landeghem, Opdenakker, & Onghena, 2002). These items were implemented in a 7-point Likert scale, ranging from 1 “not true at all” to 7 “very true”. Negatively worded items were reverse-scored such that higher scores reflect more positive attitude. Cognitive engagement was measured through group performance, which was assessed by two raters (a teacher and a researcher) on a 5-point Likert scale, ranging from 1 "Poor" to 5 "Excellent".

Results

A series of one-way between-subjects ANOVA were conducted to evaluate the effects of groups' cognitive diversity on individuals' behavioral engagement, emotional engagement, social engagement and cognitive engagement. The results revealed:

- A significant effect of cognitive diversity on behavioral engagement, $F(1, 43) = 16.41.90$, $MSE = 1.11$, $p < .001$, partial $\eta^2 = .28$ (large effect), indicating that individuals in the heterogeneous groups ($M = 6.39$, $SD = .69$) had significantly higher scores on the behavioral engagement scale than those in the homogeneous groups ($M = 5.11$, $SD = 1.29$).
- A significant effect of cognitive diversity, $F(1, 43) = 6.86$, $MSE = 1.07$, $p = .01$, partial $\eta^2 = .14$ (large effect), indicating that individuals in the heterogeneous groups ($M = 5.84$, $SD = .79$) had significantly higher scores on the emotional engagement scale than those in the homogeneous groups ($M = 5.03$, $SD = 1.21$).
- A significant effect of cognitive diversity, $F(1, 43) = 5.13$, $MSE = 1.34$, $p = .02$, partial $\eta^2 = .13$ (large effect), indicating that individuals in the heterogeneous groups ($M = 6.46$, $SD = .82$) had significantly higher scores on the social engagement scale than those in the homogeneous groups ($M = 5.68$, $SD = 1.38$).
- A significant effect of cognitive diversity, $F(1, 9) = 16.85$, $MSE = .63$, $p = .003$, partial $\eta^2 = .65$ (large effect), indicating that heterogeneous groups ($M = 3.80$, $SD = .45$) had significantly better group performance (i.e., higher cognitive engagement) than homogeneous groups ($M = 1.83$, $SD = .98$).

Discussion and conclusion

Within a group of four to five individuals, the results of our study have revealed that even having one high-ability student can bring benefits to the group in terms of group performance and individual engagement. Not only were these students more interested, attentive, and socially engaged in the class activities, but also their groups were more successful to complete the learning task. One possible explanation for the positive results of cognitive diversity revealed in the current study is that low-ability students have the opportunity to learn from high-ability student by observing, asking, arguing and other forms of interaction. From their high-ability peer's problem-solving and explanations, the rest of the group members become more and more interested by paying attention to their peers' performance and have more and more interactions with each other, which finally leads to better group performance (i.e., cognitive engagement). Although groups with four to five individuals may encounter more cognitive conflicts than dyads and triads, the consequences of cognitive conflicts are not always bad.

Based on the results of the study, the educational implication is that, to increase students' engagement, science teachers could provide them the opportunity to interact with their peers who are relatively more knowledgeable and skilled. Moreover, it may not be necessary to have a substantial number of high-ability students or learning-groups with small sizes. Relatively large groups with four to five individuals and with one high-ability individuals may be sufficient for a small group of students to learn science content.

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Technology Affordances for CSCL: A Preliminary Review

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Abstract: The pillars of CSCL depend on technology, pedagogy, and collaboration. A key question for CSCL researchers is how these variables interact to provide affordances for intersubjective meaning making. A recent meta-synthesis showed that CSCL technologies, pedagogies, and collaboration types cluster into six groups. This poster explores how the affordances identified by Jeong and Hmelo-Silver (2016) distinguish the two largest clusters, mediated inquiry with dynamic feedback and asynchronous teacher directed discussion.

Theoretical framework

The pillars of CSCL depend on technology, pedagogy, and collaboration. A key question for CSCL researchers is how these variables interact to provide affordances for intersubjective meaning making. As research regarding Computer Supported Collaborative Learning (CSCL) gains more attention, efforts towards better understanding how different combinations of technology, pedagogy, and collaboration modes interact to afford collaborative learning processes grows in importance (Jeong & Hmelo- Silver, 2014). Given the importance of examining intersubjective meaning making in collaborative learning, Suthers (2006) argued that because CSCL environments are fundamentally social, technologies that support CSCL environments should be designed for the purpose of mediating intersubjective meaning making acts. Jeong and Hmelo-Silver (2016) have identified the affordances that technology provides to the intersubjective meaning-making process. More specifically, they provide theoretical distinctions among the affordances for meaning-making in CSCL environments.

To examine joint meaning making, an examination of the variables that structure and influence interaction should be conducted, thus making the argument for examining collaboration, technology, and the seven affordances of CSCL. This is consistent with Strijbos et al.'s (2004) recommendation that CSCL design "starts with a conceptualisation of the expected (type of) interaction or changes in interaction due to pedagogical or technological tools." (pp. 416-417). They proposed that use of their framework allows one to indicate how changes in key elements of CSCL affect resulting patterns of interaction. Such an examination can then elucidate how affordances interact with CSCL pedagogies, technologies, and collaboration modalities. The research presented here aims for such elucidation.

Methods

A recent meta-synthesis of the use of CSCL in STEM domains demonstrated that research on CSCL technologies, pedagogies, and collaboration types resulted in six clusters of research studies based on the types of pedagogy, technology, and collaboration (Hmelo-Silver et al., 2017; McKeown et al., 2017). Following a systematic search and screening procedure of CSCL research articles from 2005-2014, 708 articles were reviewed, coded, and subjected to a latent class analysis. This poster focuses on the two clusters with the largest sample sizes (Cluster 1: N=393; Cluster 5: N=484), which are meaningful for their dynamic uses of technology, collaboration and level of education. Table 1 provides a description of each cluster and descriptive statistics. The original meta-synthesis used an Optimal Allocation sampling algorithm, which is a class of stratified random sampling technique to collect a subset of papers within each cluster (N=22 from Cluster 1 and N=18 from Cluster 5). These subsets are the samples for this work in progress. To illuminate our understanding of CSCL affordances in STEM education research, the study presented here employs a coding scheme of CSCL variables (technology, collaboration, and affordances). The technology, pedagogy, and collaboration coding were used to drive the cluster analysis reported in McKeown et al., while the affordance descriptions, which are provided below, were used to drive the analysis reported here. Given the diversity of the clusters, these results should provide more robust understandings of how each cluster is distinguished by the affordances.

Results

Table 2 shows the percentage of papers in each cluster that was coded for each affordances. The patterns in Cluster 1 (MIF) show that the main affordances for that cluster are establishing a joint task, support for engaging in productive processes, and engaging in co-construction. In this cluster, much of the collaboration is face-to-face synchronous but mediated by technology such as simulations. In contrast, Cluster 5 (ATD) also includes support for productive processes and co-construction but also has strong support for distributed communication and shared resources. Collaboration here is mostly asynchronous.

Table 1. Cluster Descriptions (Each represents different co-variations of technology, pedagogy, & collaboration)

Cluster Name	Cluster Description	Cluster Size (% of total)
Mediated Inquiry with Dynamic Feedback (MIF)	Collaboration: Mediated Pedagogy: Inquiry and exploration learning Technology: Dynamic tools or Other tools	25%
Asynchronous teacher-directed Discussion (ATD)	Collaboration: Asynchronous Pedagogy: Discussion or Teacher directed Technology: Asynchronous communication	31%

Table 2. Distribution of the Seven CSCL Affordances Across the Clusters

CSCL Affordances	Function for Group Members:	MIF (n=22)	ATD (n=18)
1. Establishing a joint task	Collaborate in a joint group-worthy task	100%	44%
2. Distributed communication	Collaborate through technology	23%	100%
3. Sharing resources	Share relevant resources through technology	27%	50%
4. Engaging in productive processes	Scripts guide collaboration	100%	89%
5. Engaging in co-construction	Construct shared frame of reference and build on one another's knowledge and contributions	82%	72%
6. Monitoring and regulation	Scripts aid in metacognitive awareness and regulation of learning process	45%	17%
7. Building groups and communities	Find others through shared interests	0%	11%

Conclusion

As researchers proposed, technological affordances are influential variables of the intersubjective meaning-making process (Suthers, 2006; Jeong & Hmelo-Silver, 2016). Additionally, Suthers' (2006) argument that the assessment of CSCL intersubjective meaning-making variables should be a focus of CSCL research now has quantitative justifications. The framework of Strijbos et al. (2004) also now has practical use for CSCL researchers due to its ability to capture interaction process dimensions from which further CSCL variables may be identified and explored. Future researchers should use these frameworks and findings for the purpose of fully delineating CSCL dimensions so that they may operationalize any and all of the variables that influence CSCL environments. This means that researchers can replace their current practice of analyzing learner outcomes with, first identifying the many facets of CSCL, then trying to draw learner outcome conclusions from the interactions of these variables. From this delineation, researchers will be well equipped with tools that can identify under what conditions CSCL is most effective, as well as remove potential learning barriers.

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Epistemic Game Design for Democratic and Media Education

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Abstract: This paper applies the concept of epistemic games (Shaffer, 2006) as a model for designing PurpleState Solutions. PurpleState, a Virtual Internship simulation, utilizes the concepts of epistemic frames and communities of practice as models for learning in media and democratic education. PurpleState places students in the roles of interns at a strategic communications firm who are hired to develop a media campaign on a proposed fictitious state level "fracking" ban. This design-based research project utilized a team of contributors for the design and pilot of the project. Using epistemic frames based on the professional practices of strategic communications consultants provides a dynamic and authentic model for simulations that promote the skills, knowledge, and values for active democratic citizenship.

Introduction

The US Supreme Court ruling in Citizens United v. FEC (2010), which has allowed virtually limitless funding for political media and organizing campaigns, presents a major issue for democratic education. We need to prepare young citizens who are able to evaluate media messages as well as to know how to communicate, coordinate, and take action within the mediated and global political environment (Stoddard, 2014). This paper describes the design framework and process used to create PurpleState Communications, a Virtual Internship simulation focused on developing student skills, knowledge, and values related to media and civic education. For PurpleState, we sought to provide students the opportunity to develop an understanding of the dynamic nature of media in politics and help them to develop the skills and knowledge to be both more critical of the political media they engage with and more skilled and confident in using media strategies to take political action. We argue that the use of epistemic games like PurpleState in democratic education also work toward the goals outlined in the College, Career, and Civic Life (C3) framework (Council of Chief State School Officers, 2013) and Civic Mission of Schools report (Gould, 2011).

Theory and design framework

PurpleState was designed using the model of Virtual Internships developed by Shaffer (2006a, 2006b) that employs epistemic frames and communities of practice from professions as models of learning. Thus, according to Shaffer (2006b), the epistemic frame includes epistemic understanding as well as the ways of thinking and acting of professionals within communities of practice (Lave & Wegner, 1991). In this way, "epistemic frames are the organizing principle for practices" (Shaffer, 2006b p. 227) that lead to the development of expertise through modeling the relationship between discursive practices and structures of knowledge at the level of communities of practice. Therefore, an "epistemology of professional practice" may be a better model for democratic education than an epistemology based on an academic discipline such as history, or the roles within simulations modeled after national levels of politics and power (e.g., members of congress). As noted above, traditional government simulations are more effective at reaching common government and AP government curricular goals (e.g., Parker, et al., 2013) than the skills and knowledge needed for youth participatory politics (e.g., Kahne, Middaugh, and Allen, 2014).

Methods and design process

We use the epistemic game model to develop PurpleState in an attempt to meet the following objectives: 1) understand the institutions and structures of government as they influence modern politics; 2) have the ability to research, evaluate, and communicate using evidence with old/new media; 3) be able to discuss and deliberate controversial historical or contemporary issues; 4) and to be able to take action toward civic goals using media. We use the epistemic frames of strategic communications consultants, whose firms assist candidates, political action committees, and special interest groups to develop and implement media and campaign strategies; this epistemic frame emphasizes expertise in the skills, knowledge, and values that can transfer to young peoples' actions as citizens outside of school. This virtual internship, set within a simulated community of practice modeled on a strategic communications firm, was developed based on example Virtual Internships modeled on journalism, engineering, and urban planning within STEM education (e.g., Hatfield and Shaffer, 2010) using a Virtual Internship authoring tool. As virtual interns, students work in these epistemic games with other interns and expert mentors to engage in authentic issues or problems within an immersive computer supported collaborative learning environment designed and used for the virtual internships identified above.

Results

In PurpleState, the virtual internship is modeled primarily on the work of interns from the political campaign and public affairs firms of one of the members of our design team. This member had previous experience in education and in running state level political campaigns before moving into the world of media consulting. Tasks, products, and concepts/terminology in the internship are based primarily on the work of actual interns in these firms. We also utilized sources from political communications, high school civics and government curricula (e.g., textbooks, AP Government curriculum), and work done on youth participatory politics research in the US and Europe (e.g., Binaji, Buckingham, Van Zoonen & Hirzalla, 2009; Kahne, Middaugh, and Allen, 2014). The balance between authenticity and functionality, along with maximum participation and engagement of students, was prominent in our design. We utilized an online learning environment structured similar to a project management system that allowed students to receive emails from their boss outlining tasks, to participate in chat discussions with their project team members and their online mentors (account managers), and to access materials and tasks needed as well as to submit products (deliverables).

Conclusion and implications

In this presentation we provide a framework, design process, and description of the PurpleState virtual internship that represent the first step toward developing epistemic games that work toward the goals of democratic education and media education. The conceptual framework of epistemic frames developed here, when operationalized through epistemic games, has the potential to significantly change the nature of how we teach young people to be citizens, in addition to serving as a dynamic model for reaching academic and skills goals emphasized in the C3 and Civic Mission for Schools. PurpleState is designed to engage young people in collaborative practice, a better understanding of the nature of media and its function in society and politics, and provide opportunities to engage in relevant contemporary controversial issues.

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Text Chatting in Collaborative Writing: Its Role in Coordinating Activities

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Abstract: This study investigated how a collaborative writing tool with or without a text chat option influenced collaborative writing. Sixty-two university students, paired into 31 dyads, participated in the study. Results showed that writing partners who used a chat tool contributed significantly fewer words to the actual text than participants who did not have the possibility of having discussions via a chat tool. The quality of the essays, however, was not affected by the chat tool.

Introduction

Collaborative writing provides great opportunities for learning and critical thinking. But it is also a very challenging task for the collaboration partners. In addition to formulating their own ideas and writing them down, writing partners must coordinate their writing in order to achieve a coherent and well-structured text as a final result. Benefits of coordination through communication have been found for online platforms (Viegas, Wattenberg, Kriss, & Ham, 2007) and in the educational field (Kwon, Hong, & Laffey, 2013). Accordingly, the possibility of communicating directly via a talk page or a chat tool seems to be a promising way to support coordination between writing partners and to foster collaborative writing among distributed partners. One might also argue, however, that it is not absolutely necessary to have a further communication channel to coordinate the collaborative writing process. Specific norms and expectations from a particular text genre may be sufficient to guide the writing process. In addition, the collaborative product itself directly reflects the collaboration process (Moskaliuk & Kimmerle, 2009). There is also research that suggests that direct communication, via a chat tool for instance, can even distract the writing partners from their actual collaborative task (Cress & Kimmerle, 2013). This distraction could even lead to a decrease in the quality of the collaboratively written text. Thus, the current study in which we examine to what extent it is useful and necessary to give writing partners the technological option of communicating directly via a chat tool in collaborative writing.

Methods

The collaboration situation was unstructured and no specific instructions were given besides the assignment to write collaboratively an essay about a politically charged topic, namely "Edward Snowden—hero or traitor?". Participants were explicitly allowed to express their own opinion about the whistleblower Edward Snowden and the NSA spying affair in the essay that they were supposed to write in teams of two. The study was carried out with 62 participants (mostly university students); 39 of them were female. The participants had an average age of $M = 27.68$ ($SD = 11.79$). The 31 dyads were randomly assigned to the *chat* ($n = 16$ dyads) and to the *no-chat* ($n = 15$ dyads) condition. The experimental conditions did not differ regarding sex, $\chi^2(1, N = 62) = 0.35, p = .55$, or age, $t(61) = -0.44, p = .66$. The study was approved by the Institutional Ethics Committee (approval reference: 2014/063). All participants provided full written informed consent. Participation in this study took about 60 minutes and was compensated with 8 Euros.

Procedure

The study was divided into two phases that took place at intervals of three weeks. In the first phase, participants were invited to participate in an online pre-study. Here they were asked to write a short essay (180–220 words) about Edward Snowden and the spying affair. After writing the essay, participants were asked if they were interested in participating in a lab study about the same topic. Participants who agreed were invited into the lab. Each participant was then randomly paired with another participant and randomly assigned to an experimental condition (*chat* vs. *no-chat*). In the second phase, the collaboration partners were sitting in different rooms in the lab. We used *eduPad* (http://edupad.ch/) as a collaborative writing tool. The participants were given the task of again writing an essay about Edward Snowden and the spying affair, this time collaboratively. A time limit of 35 minutes was given. To stimulate the interaction within the dyads, people's own essays and the essays of their collaboration partners that they had written in the online study were already pasted into the document. In order to analyze all of the activities, we recorded the writing process with a screen recorder (Camtasia Studio).

Measures

The quality of the text was rated by two independent raters. The raters evaluated the essays regarding *structure* and *coherence* on a 4-point grading system (see Spencer & Fitzgerald, 1993). The interrater reliability between the two coders regarding structure was $r = .86$ and regarding coherence $r = .83$. We used the mean of the ratings of the two coders in the statistical analysis. We also examined the social interactions and the verbal behavior in the dyads. In the *chat* condition we analyzed all interactions that took place in the chat tool. In the *no-chat* condition we took into consideration all activities that were identified as direct communication between the two participants.

Findings

On average, participants contributed $M = 218.05$ words ($SD = 118.90$) to the collaboratively written essay. When writing partners had the technological opportunity to use a chat tool, they wrote significantly fewer words into the actual text ($M_{chat} = 165.50$, $SD = 81.50$) than writing partners who did not have the possibility of chatting via a chat tool ($M_{no\text{-}chat} = 274.10$, $SD = 127.83$), $t(60) = -4.02$, $p < .001$, $d = 1.01$. With regard to quality, we did not find any significant differences between the conditions, either with respect to the structure of the text, $t(26) = 0.28$, $p = .79$, or regarding its coherence, $t(26) = 0.02$, $p = .98$.

We found that the dyads in the no-chat condition "undermined" the experimental manipulation, so to speak, in that they used the text editor, which was in fact meant for the preparation of the actual essay, as an auxiliary chat tool. So, after all, the dyads in both conditions had coordinated their work by directly chatting with each other. In the no-chat condition, 12 out of 15 dyads communicated with each other and coordinated their activities by integrating chat-like paragraphs into the text editor. But they differed in how they used the text editor as a chat tool. They used separate paragraphs to chat or they integrated the chat into the written essay. In some cases their chat was more like commentary on the written text. In most cases they deleted their chat conversation before they finished their essay. Our analysis of the writing process and the social interactions showed that there were many communication needs. Participants in the chat as well as in the no-chat condition engaged in relationship building (they exchanged hellos, used emoticons, and appreciated each other's contributions), they were discussing the issue with each other, and their communication was aimed at coordinating the writing process. The coordination activities included mutual corrections, guarding against misunderstandings, monitoring time, clarifying strengths and weaknesses, as well as discussing content, structure, and writing goals.

Discussion

In the study presented here the opportunity to use a chat tool had an effect only on the quantity of people's contributions to the common text but not on the text's quality. Still, communication was essential for collaborative writing in small groups. Participants in the *no-chat* condition found an alternative strategy for coordinating their writing process, which in this study meant using the text editor as an auxiliary chat tool. It seems that communication via the text editor could even be considered to be slightly more efficient, as participants needed fewer words to arrive at the creation of an essay that was written equally well. How to provide appropriate support for communication without distracting participants away from the task per se is one of the challenges to address in order to help students to become better at collaborative writing.

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Designing for Collaborative Literary Inquiry

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Abstract: Literary inquiry encourages readers to explore perspectives, experiences, and feelings of others as well as reconsider their own ideas about the world and human nature. Exploration of literary texts and making sense of the messages they convey about human experience can be supported through collaborative inquiry. This poster proposes adapting the Knowledge Community and Inquiry framework for engaging students in literary inquiry in classrooms and describes designs for a digital tool to support it.

Background

Literary inquiry encourages readers to explore perspectives, experiences, and feelings of others as well as reconsider their own ideas about the world and human nature. It also helps readers develop interpretive habits of mind that predispose them to critical analysis of all texts. We propose designing curricular units and a digital tool to support the development of knowledge and practices of literary reasoning through collaborative inquiry.

Expert studies indicate that literary scholars expect complexity and look for deeper meanings by attending to the language and structure of texts (Graves & Fredrickson, 1991; Rainey, 2016) while also relying on various types of knowledge as they read, including knowledge of other texts, genres, interpretive problems, authors, and cultural and historical contexts of texts (Lee, Goldman, Levine, & Magliano, 2016). Remaining flexible is also important as literary texts are open to multiple interpretations that may depend on one's critical lens or one's own experiences of the world (Lee et al., 2016). Research around instructional interventions to support students in engaging in the practices of literary reasoning indicates the importance of sequencing texts and tasks, providing students with opportunities to learn explicit strategies related to literary interpretation, and using class discussions to build understanding (Applebee, Langer, Nystrand, & Gamoran, 2003; Lee, 2007). Designing learning environments to support literary reasoning also requires analysis of text and task complexity for building knowledge around content, theme, and structure (Lee & Goldman, 2015).

Our design adapts the Knowledge Community and Inquiry (KCI) model (Slotta & Najafi, in press) to support collective inquiry while building a literary knowledge community. KCI is based on four principles:

1. Students work collectively to create a knowledge base that is indexed to a specific content domain.
2. The knowledge base is accessible as a resource as well as for editing and improvement by all members.
3. Collaborative Inquiry activities are designed to address the targeted domain learning goals, using the knowledge base as a primary resource and producing assessable outcomes.
4. The teacher's role and orchestrational obligations must be clearly specified within the inquiry script.

Despite previous enactments of KCI having been in science curricula, these principles ground a model that has sufficient flexibility to support designs in other disciplines. We propose to use this model to guide the design of learning environments to support students in developing the skills and practices of literary reasoning.

Designing for literary inquiry

In initially considering adapting the KCI model for literary inquiry, two questions arose: 1) What is the object of inquiry? 2) What might the knowledge base ideally consist of? In answer to the first question, Lee et al. (2016) propose three main goals of literary inquiry: exploring complexities and dilemmas of human experience, analyzing relationships between form and content, and considering connections among texts. In other words, the object of literary inquiry is the text itself but also the messages the text conveys about human experience. To explore the text and its messages, activities might be designed to support student production of a knowledge base that consists of criteria for recognizing and interpreting themes, ways to identify structural elements and how they convey meaning, and information about history or context related to the focal texts.

As an example, we will describe a unit on dystopian fiction, a genre whose function is to critique aspects of human society, focusing on issues such as equity and discrimination, mastery of the natural environment, and human enslavement to technology. Ideally, exploring this genre of text will encourage inquiry into and analysis of these issues in students' own experiences of the world. Knowledge of and criteria for constructing interpretive arguments around these social problems could be built through students' exploration of real world issues related to the themes arising in the focal text(s). Figure 1 illustrates how our digital tool might support building this thematic knowledge base from students' contributions through collective brainstorming.

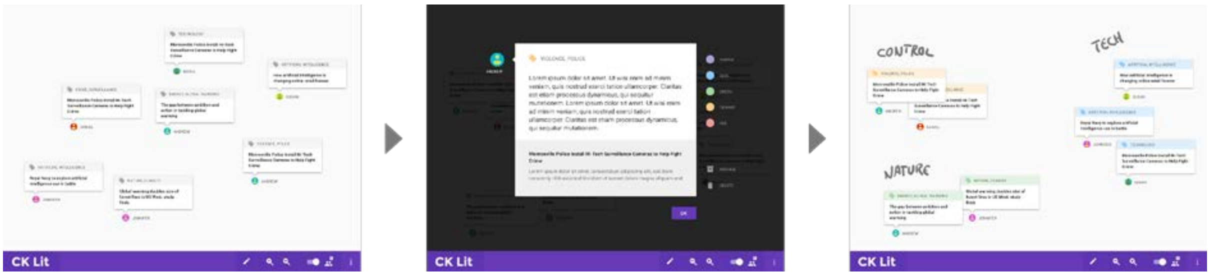

Figure 1. Smartboard app supporting collective brainstorming for categorization of student's notes.

A similar interface can be used to support building knowledge around literary devices, genres, or related texts. For example, students could read short dystopian stories or view dystopian film clips to build knowledge around typical characteristics of the genre (e.g., government control, the dystopian protagonist) The digital tool would then hold easily accessible information and lists of criteria for students to use in making sense of the structure and messages of texts. The sequencing of texts and tasks, including when and how the knowledge base is constructed, relies on consideration of defined learning goals and the developmental and cultural characteristics of the specific community of students (See Sosa, Hall, Goldman, & Lee, 2016).

Besides the building of a common knowledge base, the digital tool must also support the exploration of multiple interpretations and perspectives on texts and the construction of literary arguments with interpretive claims backed by textual evidence and appropriate reasoning. Figure 2 shows an example of an interface where this exploration and argumentation might take place, with space to make, support, evaluate, and discuss claims with others. Finally, as an assessable outcome and external representation of their reasoning, students would construct written arguments with access to the knowledge base as well as the community sense-making and discussion of texts. The digital tool will provide a permanent record of their collective knowledge and processes both for their reference and for the teacher's formative assessment.

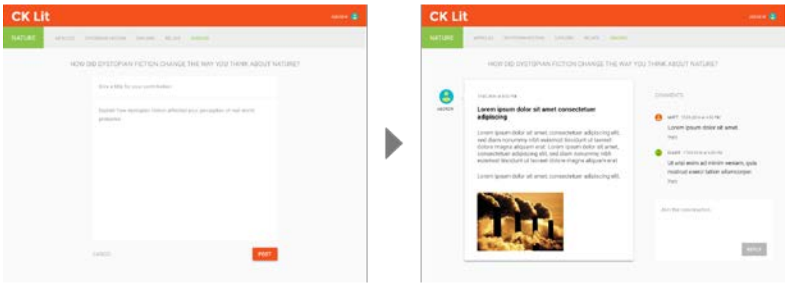

Figure 2. Mobile app supporting student reasoning and discussion.

Our poster will further elaborate on the principles behind our design and illustrate a unit sequence of texts and tasks as well as how our digital learning environment supports this type of collective inquiry.

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Exploring the Road to Place-Based Collaborative Learning via Telepresence Robots

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Abstract: This study explores a design for Place-based collaborative language learning via telepresence robot at an arboretum located on the campus of an American University. We argue that telepresence robots can support virtually immersing learners into outdoor environments. To understand the affordances provided by telepresence robots we conducted a pilot study, in which EFL learners in China interact with a native English speaker by controlling the robot as they navigate through the garden.

Introduction

This study explores the viability of Place-based collaborative language learning via telepresence robot. Place is important for learning, especial when the learning objectives involve environmental, social and cultural aspects (Holden, Sykes, 2011). At the same time, many places are inaccessible to most international adult learners. Therefore, telepresence robots could be a promising technical tool to mediate time, space and access for learners on a global scale. The approach to support collaborative learning has been expanded from in-person communication to online communication via email, discussion forums, and video-conferencing. This paper aims to explore the applicability and the affordances of using mobile telepresence robots to mediate collaborative learning in outdoor spaces.

Why place matters

Learning Sciences research has shown that "the most effective learning occurs when the learning is situated in an authentic, real world context" (Krajcik & Blumenfeld, 2006, p.319). However, formal educational environments are typically place agnostic; both physically, where classrooms isolate the learners from the outside world, and in discourse, where textbooks, syllabi, and instruction are generally standardized across courses, and thus make little reference to actual lived contexts of their subjects. For example, as Larsen-Freeman (2013) reported, a student showing adequate grammar skills on a standardized multiple-choice language test given at school may not apply them in authentic communicative situations. Place-based education (Sobel, 2004) advocates designing curriculum and activities to make school-based learning more relevant to everyday life through a focus on local issues. We argue that Place-based collaborative experiences can engage adult learners in activities within a global environment to advance meaning making. We also suggest a relatively inexpensive solution that could have wide applications to other Place-based fields such as ecology, history and geography.

Why telepresence robots

At global scale only a few foreign language learners have opportunities to travel to target-language countries for numerous reasons. One solution to address this issue of access is using technology to facilitate rich and authentic learning experiences. The term telepresence, firstly proposed by Minsky (1980), refers to a set of technologies that give remote users the feeling of actually being present at a remote location. By using telepresence robots, which can be controlled remotely online and support video chatting, students can have access to those environments. Also with the development of mobile technology, some telepresence robots have embedded mobile devices like iPad or iPhone as a core component, which makes the cost of those robots significantly reduced and more affordable for widespread use.

Participants and methods

We conducted a pilot study using the public botanic garden on an American university campus as our place-based setting. A native English speaker, acting as tour guide, conducted one-on-one garden tours with five adult language learners in China. First the learners take a short pre-test to gauge their English proficiency. Next, we designed an hour-long activity based on four main locations in the garden. Each location has associated talking points and vocabulary and is allocated roughly 10 minutes. After the activity, the learners reflect on their experience.

Figure 1. An EFL learner in China tours the garden.

Findings

From a technical standpoint, we found that the learners communicated with the native speaker via the telepresence robot quite smoothly. We did encounter some Internet lags, which caused delays of video and/ or robot movement. These incidents were greatly diminished however when we switched from the publically available wireless Internet to a personal Internet hot spot via mobile phone with 4G connection. In terms of pace, we kept the robot at a very slow strolling speed, which gave the most control to the learners and was also able to handle cracks within the pavement.

From a learning perspective, the EFL learners were virtually immersed in the garden and could observe how the garden visitors engaged in social activities like playing sports, walking pets, and general familial interactions. The physical environment around the telepresence robot, such as the trees, flowers, and sculptures encountered in the garden tour, allowed for conversational topics to emerge naturally as learners moved along the route. For example, a group of three elderly women were intrigued by the learner depicted on robot screen, and talked enthusiastically with the learner, asking them about where they lived and what they studied. Despite being “off script” the learner negotiated the impromptu conversation and afterwards described her enjoyment, “I felt so honored that they wanted to talk to me!” We found that socio-cultural space of the garden and embodied agency provided by the robot, helped students make meaning of vocabulary, phrases, and idiomatic expressions in a rich and authentic language context. We also observed how the teacher/tour guide engaged in various teaching techniques based on the learner such as various kinds of role taking and the negotiation of non-scripted and dynamic physical environments.

Discussion

The study’s main objective was to demonstrate viability and technical applicability of telepresence robots for a place-based, language learning framework. During this initial phase, we looked to understand learners’ motivation, social interaction and embodied agency through one-to-one instruction. However, we anticipate continuing the study with several telepresence students in order to investigate how learners engage in collaborative learning and how instructors can facilitate different types of collaborative interactions, like argumentation, think-pair-share, team-based learning, peer assessment, group problem solving, etc. For instance, after a tour and giving a brief introduction to the environment, the native speaker can ask the remote students to discuss topics like ‘which site in the garden will be most appropriate for a wedding ceremony?’.

In addition, the learners in our study also gained some understanding of regional American culture and site-specific knowledge. This may expand the use and scope of similar robot-mediated place-based learning to other disciplinary contexts such as history, biology, and geography in future research.

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The Effect of Peer Interaction on Task Efficiency and Learning Engagement in Digital Game-Based Learning

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Abstract: This paper describes the way in which middle-school students' peer interaction during digital game-based learning mediates their task efficiency and learning engagement. This poster presents preliminary findings from the analysis of behavioral data collected on students' game play. A correlation analysis was performed to explore the relationship between peer interaction and task efficiency, and a one-way ANOVA was conducted to investigate the possible effects of peer interaction on task efficiency and learning engagement.

Introduction

Collaborative learning approach, especially peer interaction, is recently designed and integrated into digital game-based learning (DGBL) to enhance learning engagement. In particular, peer interaction in CSCL has been reported to support the exchange of ideas in problem-solving tasks, and enhances their learning motivation (Ge & Land, 2003). However, peer interaction, as a multi-tasking behavior, can be a distraction to learners during game play. Task-irrelevant peer interaction may reduce students' performance in game-based learning (Zhang, 2015). To integrate DGBL into the school education, it is critical to ensure that learners will achieve the learning goal or perform the targeted problem-solving task efficiently. In this study, task efficiency (TE) measures the degree to which learners are engaged in task-relevant game-play actions. TE will also indicate the quantity of the game-based problem-solving tasks that learners complete given a limited time frame. TE can act as an indicator of efficient learning under various constraints (i.e., time or cognitive resources) (Hoffman & Schraw, 2010). Learning engagement (LE) measures the degree to which learners are cognitively involved in game-play. It relates to learners' content-based task engagement as well as problem-solving involvement. Peer interaction, LE and TE are all salient facets of DGBL, yet it is unclear how peer interaction accounts for TE and LE in game-play. To better understand this obscure relationship, the goal of this study was to address two research questions: (1) Does peer interaction mediate TE in game-based learning? (2) Does peer interaction mediate LE scores in game-based learning?

Procedure

The sample in this study consisted of fourteen 6th grade students who completed problem-solving tasks in the *Earthquake Rebuild* game (Ke, 2016). The overall game goal of E-Rebuild is to rebuild an earthquake-damaged space to fulfill diverse design parameters and needs. For example, a game task in E-Rebuild asks the player to rebuild a multi-room shelter structure by referring to a pre-quake house model/floor plan and using a minimum number of shipping containers. The targeted math content topics by E-Rebuild are aligned with the Common Core State Standards (CCSS) for mathematics Grade 6-8 (CCSSI, 2010). Data were collected via screen and video capturing of students' game play actions and utterances. We used BORIS software to conduct a systematic behavior analysis with the data collected (Friard & Gamba, 2016) . A total of seventy-one 40-minute video files were analyzed. A systematic coding scheme was designed and developed via cross-case comparison and categorization analysis. Five coders independently coded the same 20% of the video files and did peer debriefing to achieve 100% inter-rater agreement. The coding theme was iteratively refined during the coding process. The final codes related to this current study were learning engagement, peer interaction, off-game, and play. Each code tags a state event, and each instance of the event is associated with a time duration measure.

Table 1: The list of each code in data analysis

Codes	Definition
Learning engagement	Gaming actions that are problem-solving or math content oriented
Peer interaction	Game talk with peers but not task-focused
Off-game	Not gaming or task-engaged
Play	Gaming that is not learning relevant

For each participant, the total time a participant spent in each game behavior was calculated. TE and LE scores were then computed based on these time-duration measures. To calculate both variables, this study used *Likelihood model* to measure TE (Hoffman & Schraw, 2010). The model relies on the rate of change between two variables. Specifically, TE in this study measures the proportion of task-oriented time in the total game-playing time. Figure 1 shows the equations for TE and LE scores.

$$\textbf{Task Efficiency Score} = 100 - \left(\frac{\{(Time\ for\ OffGame + Time\ for\ interaction)\}}{Total\ Game\ playing\ Time} \times 100\right)$$

$$\textbf{Learning Engagement Score} = \frac{Time\ for\ Learning\ Engagement}{Total\ Game\ playing\ Time} \times 100$$

Figure 1. Equations used to calculate TE and LE scores.

Analysis and results

We conducted a correlation analysis to identify the relationship between peer-interaction and TE scores. The two variables were significantly and negatively correlated ($r_{14} = -0.91, p < 0.01$.). The more time learners spent in peer interaction, the lower their TE scores would be. But, no significant correlation between peer interaction time and LE scores was found. We also conducted a one-way ANOVA to investigate the effect of peer interaction involvement level on LE and TE scores. We divided the participants into two subgroups based on the peer interaction involvement level. Participants being in the top 30 percentiles in terms of the peer interaction time were considered *Peer-Interactive*, while the others were considered *Low or Non-Peer Interactive*. There was significant group difference in the TE score ($F_{1,8} = 8.36, p < 0.05$). *Low or Non-Peer Interactive* had higher TE scores than *Peer-Interactive* did. There was no significant difference in LE between the two categorized groups ($F_{1,8} = 2.33$, $p = 0.18$). Yet the group with *Low or Non-Peer Interactive* had numerically higher LE scores than the *Peer Interactive* group did.

The aforementioned results demonstrated the potential effect of peer interaction on TE and LE scores. Statistically, the correlation analysis revealed that peer interaction is related negatively to TE. Students might spend time interacting with their peers regardless of their task progress or performance status. This interpretation is supported by significantly different TE scores by peer interaction in a univariate analysis. There was no statistically significant effect of peer interaction on LE, though there is a potential trend that less peer interaction in game-play was associated with a higher level of LE.

Conclusion

This study demonstrated the way in which peer interaction mediates TE and LE in digital game-based learning. Based on the preliminary findings, peer interaction during game play may actually reduce game-relevant TE. It should be noted that the game players' peer interactions in this study captured game-relevant and/or task-relevant peer interaction as well as game-irrelevant or task-irrelevant social talk. These results imply that game designers should purposefully design collaborative learning scaffolds that facilitate task-relevant peer interaction. Future research should examine specific types of peer interactions that reinforce game-relevant TE and LE, and in-game supports that enhance learners' TE.

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Breaking the SEAL: A CSCL History Teaching Methodology to Support Transition Into Undergraduate Education

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Abstract: This paper reports on the pilot project, Breaking the SEAL, that supports second level students undertaking historical research projects. This CSCL intervention incorporates the key 21st century skills of collaboration, critical thinking, academic writing and digital skills. Longitudinally, we hope to better understand how these embedded skills benefit participants upon entry to third level education. Our preliminary findings, reported here, focus on the suitability of history as subject for the development of such transitional skills.

Introduction and background

In Ireland, and internationally, progression rates to third level education are realised between 60-70%, however it is often the case that such students are deficient in 21st Century skills and their application in educational contexts (Smyth, Banks & Calvert, 2011). Pressures such as living away from home and looking after ones' self for the first time are compounded by the expectation of skills application upon entry to third level education (Smyth *et al*, 2011). We broadly define such skills as: collaboration, critical engagement, academic writing and digital skills. Breaking the SEAL (Student Engagement with Archives for Learning) aims to introduce and nurture the aforementioned skills within a mandatory historical research project undertaken by history students within the upper level second level education system in the Republic of Ireland. While second level education is inherently individualistic, as a consequence of high stakes examinations, opportunities for collaboration are limited although not nonexistent. The history research project structure allows students to work together to compliment the individual research interests of group members. This research study seeks to explore how participation in the programme can enable students engage in a deeper learning experience through shared meaning making in the construction of their artefacts (Stahl, 2002) within a Computer Supported Collaborative Learning (CSCL) environment while concomitantly engaged in a process of learning how to learn (Hmelo-Silver, 2004). The aim of this research project is therefore, twofold. Initially, we aim to establish the curricular subject of history as an area that facilitates the development of the aforementioned, transitional, 21st Century skills. Secondly we aim to investigate, longitudinally, how effective the designed CSCL intervention is in preparing such students for participation at third level education. This paper reports on the pilot application of this project to satisfy the initial aim of this study.

Methods

Participants and setting

The participants in this study were all second level students aged between 16 and 17 years. All students, in year one of a two year cycle, were studying history for higher level examination and intended to progress into a variety of third level disciplines. History is not a mandatory subject for examination and experiences a lower yearly uptake, 50% less, than other optional subjects such as Geography. A core component of the senior cycle history syllabus is the compulsory Research Study Report (RSR) that accounts for 20% of the available marks awardable. Students may choose any topic they wish without restriction, however many struggle with aspects of the task such as: critical engagement with sources; construction of a coherent academic narrative; and in many cases the digital skills required to access information. Prior to the establishment of this programme no formal third level support programmes existed that supported students through this process

Designed pilot Intervention

The design variables (Ciolfi & Bannon, 2003) - collaboration, engagement, narrative construction and technologies were adopted and adapted from a previously established Design-Based Research (DBR) (Barab & Squire, 2004) model, 'TWO-CENTs' (Flynn, 2016), to frame the study at second level education. The same variables would then be used to analyse the effectiveness of the intervention within that context. Participants were invited to provide their chosen topics of research and subsequently supported by relevant primary sources from the library archives and then secondary sources from the university library catalog. Participating students were hosted on campus for a day where they received a tour of the archives and access to artefacts as well as three targeted workshops - selection of primary and secondary sources; interpretation of selected source; and academic writing skills. The CSCL environment included access to digital resources held by the university, online points of information as well as the existent digital second level school environment. As a follow up to the on-campus visit we visited students at their school. In the interim they were required to further research their work both at the local library and through the university online catalog as part of the CSCL environment. In addition, students were provided with a digital template for the development of their academic poster presentation. During the school visit students used iPads, provided by the university, to develop their academic poster content and refine their image selections. Finally, participants' families and friends were invited onto campus for a formal academic poster session where students engaged with their audience to present their findings.

Data collection and analysis

The research study design variables acted as a lens through which a thematic analysis of the triangulated data could be carried out. Triangulated data, gathered from participants (N=24), included a short pre and post-intervention survey, student video interviews, interview with co-operating teacher and the participant constructed artefacts in the form of the academic posters presented.

Preliminary findings

23 out of 24 (96%) digital submissions evidenced a collaborative aspect to their RSR projects. 92% of submitted RSR projects evidenced critical engagement with others and sources, even on unrelated RSR projects and authors indicated that this engagement made the experience more enjoyable and the construction of their narratives easier. 100% of participants indicated that their exposure to technologies as part of the CSCL environment provided was preparing them for life at third level education. 100% of participants also indicated that the subject of history was the only subject where they were learning these skills within the curriculum and that was attempting to prepare them for their future engagement with third level education. All participating students indicates that they were willing to participate in a longitudinal study.

Discussion and conclusion

The aims of this study were articulated as twofold. Initially, as a pilot project, we sought to test the suitability of the subject of history as an area suitable for the development our broadly defined 21st century skills. The preliminary findings of the pilot project indicate that, when supported by a CSCL environment, the subject of history can facilitate the development of important 21st century skills. The next phase of this research project will expand out to three participating schools (N=105) to mainstream the pilot study and further refine the programme. The CSCL environment will be expanded to include a dedicated website linked to the digitised achieves and university catalog facilitating mobile support for students as indicated by the design model 'TWO-CENTs'. The participants from the pilot project and subsequent applications of the programme, will be tracked through their matriculation to third level in 2018 to ascertain to how effective the Breaking the SEAL programme was in helping them make the transition from second to third level education. Thus, extending the research project to address the second aim of the study.

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The Effect of Varied Gender Groupings on Science Knowledge and Argumentation Skills Among Middle Level Students

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Abstract: The purpose of this mixed-methods study was to explore the effect of different types of gender groupings on 7th graders' science knowledge and argumentation skills in a computer-assisted project-based learning environment in the United States. A total of 58 students were engaged in the collaborative argumentation process in same-gender groupings (the treatment condition), while 46 students were engaged in the collaborative argumentation process in mixed-gender groupings (the control condition). Verbal collaborative argumentation was recorded and the students' post essays were collected.

Introduction

The *Next Generation Science Standards* (NGSS) (National Research Council, 2012) identified "engaging in argument from evidence" (p. 12) as one of the essential eight science practices for students in the United States. As a common practice for scientists, argumentation is a process for constructing explanations and identifying solutions. A number of researchers (Kuhn, 1993) have defined essential elements of argumentation: position, reason, evidence, counterargument, and rebuttal. A position refers to an opinion or conclusion on the main question that is supported by reason. Evidence is a separate idea or example that supports reason or counterargument/rebuttal. Counterargument refers to an assertion that counters another position or gives an opposing reason. A rebuttal is an assertion that refutes a counterargument by demonstrating that the counterargument is not valid, lacks as much force or correctness as the original argument, or is based on a false assumption.

Recent studies (Scheuer, Loll, Pinkwart, & McLaren, 2010) have explored the potential of graph-based computer-assisted programs in improving learning outcomes and facilitating cognitive processes. The present study aimed at addressing the limitations of existing research (Dwyer, Hogan, & Stewart, 2012) on graph-based computer-assisted programs by engaging students in a project-based learning environment that involves using a computer-assisted program to support collaborative argumentation. Additionally, a growing body of research (Ding, Bosker, & Harskamp, 2011) has studied the influence of gender groupings on students' learning outcomes in computer-supported collaborative learning. Therefore, the present study also aimed at exploring how different types of gender groupings influenced the argumentation process in a graph-based computer-assisted project-based learning environment.

The following research questions were addressed:

1. What are the differences in argumentation skills (as measured by reason, evidence, counterargument, and rebuttal) between students in same-gender groupings (the treatment condition) and students in mixed-gender groupings (the control condition)?
2. What are the differences in science knowledge (as measured by scientific facts, scientific explanations, and valid scientific facts/explanations) between students in same-gender groupings (the treatment condition) and students in mixed-gender groupings (the control condition)?
3. If there was a difference in argumentation skills, in what ways would the graph-based computer-assisted program support students' development of argumentation skills in different types of gender groupings?

Methods

This mixed-methods study was conducted in a 7th grade middle school science classroom in suburban Chicago, U.S. There were six classes. A total of 58 students (29 females and 29 males, 3 classes) comprised the treatment (same-gender) condition while a total of 46 students (24 females and 22 males, 3 classes) were in the control (mixed-gender) condition. The composition of the students' ethnic background was diverse. The diversity of ethnic background was approximately uniformly distributed across classes. The students' science performances ranged from low to high. The same science teacher taught all students. Each of the six classes was randomly assigned to either the treatment or control condition. In both conditions, the students worked in teams of three to four. Each team in the treatment condition was engaged in verbal collaborative argumentation with their same-gender team (e.g., all female students) members and then argued with the other same-gender team (e.g., all female students) using the graph-based computer-assisted program. The teams in the control condition also engaged in verbal collaborative argumentation with their same-gender team members (e.g., all female students) and then argued with the other different-gender team (e.g., all male students) using the graph-based computer-assisted program. In both conditions, verbal collaborative argumentation was recorded with a digital camcorder. After one week of the argumentation activity, the students in both conditions were asked to write post essays. The topic was, "If the US could fund only one form of alternative energy, which one should you select?" Based on Kuhn's (1993) definition of individual argumentation skills, the students' essays were scored for argumentation skills. The researchers used researchers' developed rubric to measure science knowledge in essays. The researchers followed the frameworks suggested by Kelly and Crawford (1996) to analyze how the computer-assisted program supports the collaborative argumentation process.

Findings

There are no statistically significant differences in science knowledge between the treatment and control conditions either for the combined set of students, or for females and males considered separately. For the combined set of male and female students, MANOVA indicated no statistically significant gender-grouping effect on the combined set of argumentation skills outcomes. Similarly, no significant gender-grouping effect was observed among females. However, a marginally significant effect for gender grouping on the combined set of outcomes was apparent for males [$F(4,46) = 2.54$, $p = .05$]. Examination of the canonical loadings (i.e., structure coefficients) (-0.43, 0.11, 0.15, 0.82), for reason, evidence, counterargument, and rebuttal, respectively) indicated that the gender-pairing effect was strongest for rebuttal. Univariate ANOVA analyses also affirmed a statistically significant gender-pairing effect on rebuttal [$F(1,49) = 7.34$, $p < .01$], with a moderate-to-large effect size ($\eta^2 = .13$). Here, the mean rebuttal score among male students for the mixed-gender grouping ($M = 1.68$, $SD = 1.25$) was higher than the mean score for the same-gender grouping ($M = 0.83$, $SD = 1.00$). A qualitative analysis was conducted to examine how the computer-assisted program supported students' development of argumentation skills in different types of gender groupings. Female teams, regardless of which types of gender groupings, demonstrated balanced participation in the construction of argumentation maps in the program. Male teams in same-gender groupings (the treatment condition) demonstrated unbalanced participation in the construction of argumentation maps in the program.

Conclusions and implications

The study showed that it was an advantage for female students when they were able to engage in the process of collaborative argumentation process with female team members. However, it was a disadvantage for the male students to engage in the process with the male students. Researchers or educators could use this observation to plan computer-assisted collaborative learning in different stages.

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Democratic Engagement: A Progressive Approach to CSCL

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Abstract: This poster presents formative research toward a "Progressive CSCL" model. The model proposes that Dewey's (1916) framing democracy as "a mode of associated living and conjoint communicated experience" provides the foundation for CSCL. From there, related progressive values provide a point of contrast with dominant educational paradigms. The premise of the model is that a collaborative culture founded on progressive principles is foundational: If we get that right, CSCL becomes not only easier, but expected.

Summary

Many schools in the United States and elsewhere place an inordinate focus on performance-driven, individually-based student accountability (Ravitch, 2013). With this, they often fail to pay sufficient attention to the quality of the learning spaces. In place of meaningful engagement, students are pressured to achieve high scores on assessment tasks which – by design – are outside of the context of the students' lives. Performance on these tasks is then used to rate and rank teachers, schools, and school districts. While the merits of this approach are the subject of a great deal of educational and political debate, the focus here is on a much narrower concern: the extent to which this focus on individual performance on context-free tasks makes computer supported collaborative learning (CSCL) difficult to implement in meaningful ways.

This presentation offers a theoretical framework and preliminary research undertaken with a goal of countering this dominant paradigm of schooling. Specifically, it will be argued that educators looking to nurture 21st century CSCL environments would do well to revisit and revitalize progressive educational values. Starting from John Dewey's (1916) framing of democracy as "a mode of associated living and conjoint communicated experience" and then moving into a careful consideration of what makes a good experience, an effective counterpoint can be raised against individualistic approaches to education. Key elements in this effort include elements of Dewey's further work in framing democracy and experiences, as well as the work of other progressive educators. Among these. David Hawkins (1974) plays a central role, as the model draws on his advocacy for building a base of experience by "messing about" and in his analysis of collaborative inquiry in an "I – Thou – It" triad where multiple people engage with, discuss, and reflect on intriguing phenomena. Related progressive educational values provide further support. As educators create programs drawing on progressive values such as these, the learning environment is made more hospitable to CSCL efforts than is typical in current narrowly framed educational spaces.

To summarize, the Progressive CSCL Model has three core components which are disaggregated here. In practice, the model becomes recursive as each component feeds the others.

- ***Direct engagement*** in projects through work that meets Dewey's (1938) criteria for experience, including continuity with a learner's previous work, interaction, a focus on continuous growth, and building toward a progressively complex organization of the learner's (and the community's) overall experience.
- ***Generation and use of inscriptions*** (including text, graphs, tables, models, and simulations) that emerge from or extend experience (Brizula & Gravel, 2013; Lehrer & Schauble, 2002). Phrased broadly, creation and use of these inscriptions serves both to record experiences as they happen, and – through critical use of the inscriptions – become an experience unto itself, fully consistent with Dewey's criteria just cited.
- ***Collaborative discourse*** (Gallas, 1995; Gerken, 2012) which draws on and revisits both the experience space and the inscriptions. Rich discussion enables continuous growth well past what is possible in traditional classroom "discussion" which focuses primarily on a teacher checking student answers.

Done well, a classroom reflects these values as part of its metaphorical DNA, and from there, the computer technology becomes a valued tool supporting the collaborative work being undertaken.

Presentation

Discussion during the poster session will engage participants in envisioning how the Progressive CSCL model plays out in practice, and how it contrasts with more individually-focused use of the same tools common in traditional learning contexts. To make the model readily accessible in the context of a poster session (i.e., without need for more more than a cursory orientation), discussion will be rooted in a visual depiction of how the model contrasts with typical practice, supported by micro-vignettes of student work in projects led personally by the author. Each micro-vignette will be supported by at least one inscription (i.e. map or graph) central to the collaborative inquiry at hand, and a photograph showing the students at work on the project. One example would be work currently underway with 10 and 11 year old students using agent-based modeling tools to investigate local ecological issues. Here the fusion of the students' field experience and computer-based modeling — anchored by the Progressive CSCL Model — provides a richer experience than would be possible through individual use of pre-fabricated visualizations that are common fare in many modern science curricula.

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“You switch, and I press”: Comparing Children’s Collaborative Behavior in a Tangible and Graphical Interface Game

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Abstract: In this study, we examine collaborative differences between children’s interactions with a tangible user interface and their interactions with an isomorphic digital interface. We observe pairs of children interacting with both interfaces and trace how their body language, verbal communication, and collaborative behavior differ across their interactions. Our preliminary findings indicate that the tangible interface supports greater collaboration between participants through affordances such as greater visibility and multiple access points.

Introduction and background

Recent research on labor markets has argued that the most stable and well-paying jobs of the coming decades will require not only high levels of technical skills, but also high levels of *social skills* (Deming, 2015). The argument is that collaboration in teams of specialized individuals will be essential—those who bring real skills *and* an ability to work together will be the most successful. In other words, it is not enough for young people to learn skills like computer programming. They also need to know how to collaborate effectively.

In this study, we investigate the collaboration of young children playing a computer programming game called Osmo Coding (see Hu, Zekelman, Horn, & Judd, 2015). The game uses the front-facing camera of a tablet computer to track physical programming blocks on a tabletop surface (Figure 1a). These blocks control the motion of a character who roams about a virtual world in search of strawberries on the screen of the tablet computer.

We are particularly interested in the role of tangible interaction in shaping children’s collaboration and learning. Tangible interfaces have been shown to support collaborative learning by building on the cultural familiarity of everyday objects (Horn, 2013), multiple access points to prevent interaction bottlenecks, and greater visibility and legibility than digital counterparts (Shaer & Hornecker, 2010). While prior work has demonstrated that tangible interfaces can promote collaborative engagement (Horn, Crouser, & Bers, 2010), few studies have explored how tangible interactions shape the ways in which young children collaborate around shared interfaces. To better understand these factors, we have created a comparison condition that allows children to play the same game using a touchscreen interface containing digital representations of the programming blocks (Figure 1b).

(a) (b) (c) (d)

Figure 1. a) The tangible condition uses physical programming blocks; b) screen shot of the screen-based condition; child pair interacting in the tangible (c) and screen-based (d) conditions.

Methods

We recruited fourteen children between five and eight years old from a local community center (nine girls, five boys). Children were paired by their teacher (seven pairs), and the pairs played with each version of the game for approximately twelve minutes each (Figures 1c, 1d). To reduce order effects, some pairs started with the screen-based interface, while other pairs started with the tangible interface. All sessions were video recorded.

To analyze session videos, we are combining qualitative, inductive coding (Strauss & Corbin, 1998) with quantitative analysis. First, we created categories of nonverbal communication such as body posture, hand and arm position, and visual attention and coded these categories by watching the videos without sound. Through this coding, we hoped to gain insight on the nature of nonverbal cues within our sessions and how they relate to collaborative behavior. We then created a second set of categories describing collaborative actions between participants. These included actions such as proposing taking turns using the interface or preventing a partner from using the interface. The videos were then viewed again, this time with sound, and coded for collaborative actions. With both sets of categories coded, we then computed the aggregate duration and number of occurrences of each code and then compared them across our conditions. We will continue to refine this coding scheme with the ultimate goal of better understanding collaborative behaviors within the sessions.

Preliminary analysis and findings

We have fully coded two of the seven pairs using the current coding scheme. Of these two pairs, one pair started with the digital interface, while the other started with the tangible interface. In this paper, we present some of our preliminary quantitative analysis. Since our current sample size for comparison is low, we state notable characteristics of the data, while continuing to look for evidence that contradicts these trends.

In the sessions studied thus far, we observed that participants seem to assume either an "active" or "passive" role that remains fairly consistent across both conditions. Generally, the active user spends more time physically interacting and is more likely to interrupt the other user and assume control over the interface. The "passive" user, while engaged and attentive, seems to have overall less direct physical contact with the interface.

Keeping the distinction between active and passive participants in mind, we analyzed our coded data while looking for overall themes in how these roles change across the tangible and digital implementations. Analyzing the nonverbal communication codes, in the digital interface active users were more likely to orient their bodies straight towards the tablet, whereas in the tangible interface they were more likely to exhibit a slight directional tilt towards their partners. In the tangible implementation, passive participants spent more time looking at the game screen and coding blocks, held more open arm postures, and spent more time interacting physically.

The findings in our collaboration codes helped explain some of our findings in the nonverbal communication codes. For example, passive participants had more options to interact with the tangible interface—they could manipulate blocks that the active participant did not hold control over, and pass blocks over to the active participant. Consequently, the passive participants were more physically active in the tangible implementation. Consistent with the theory that tangible interfaces enhance legibility due to the visibility of physical objects, and thus promote more group awareness and coordination (Shaer & Hornecker, 2010), passive participants were more verbally active in the tangible interface and provided more suggestions to the active participant. In terms of the active participants, while there was little change in their quantity of physical actions across both interfaces, they were more likely to engage in *defensive* action in the digital implementation than in the tangible one. For example, they might swipe their partners hand away or place their arms around the interface. Interestingly, passive participants were more likely to engage in defensive action in the tangible condition. Lastly, we note that in the digital interface, participants tended to suggest taking turns using the interface, whereas in the tangible interface, they were more likely to suggest dividing responsibilities, such as one participant changing the direction of movement and the other participant deciding when to execute commands.

Our preliminary results indicate that the tangible user interface supports greater collaboration between participants through affordances such as greater visibility and multiple access points. In order to ground our findings in statistical analysis, we plan on creating a more efficient means of quantifying comparisons and increasing our sample size.

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Transformational Change in Humanistic Learning Communities: A Case Study of Person- and Idea-Centered Integration

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Abstract: In this paper we consider a unique CSCL environment where an unusually large emphasis was placed on having students get to know themselves and each other as learners as they studied ideas about learning. Framing this design as a 'humanistic learning community', we claim that students' transformational changes come about when they consider their personal experiences as learners, both in the past and present, in relation to the more abstract, conceptual ideas about learning. We present an analysis on the different activities of a humanistic learning community. We show how considering person- and idea-centeredness explains the significant transformational changes that the participants make. We conclude with a discussion about what this conceptualization offers the design of CSCL environments.

Keywords: CSCL; Encounter group; Humanistic learning community, Transformation; Wiki

This paper is an outcome of a decades-long design experiment at the Educational Technologies Graduate Program at the Educational Technologies Program at the University of Haifa, Israel. In 2006-2007, an introductory course to the program was originally designed by the second author of this presentation, and has since been refined and studied through annual iterations. Called "Challenges and Approaches to Technology-Enhanced Learning and Teaching" (CATELT), the course was designed as a classroom learning community with the dual goals of introducing students to the foundations of the learning sciences, as well as inducting them to the broader educational technologies community, both within the program and within Israel. Over the years, CATELT had become a highly popular course due to its unusual design where students spent significant amounts of time reflecting upon their learning as individuals and as a learning community, both in relation to their learning experiences inside and outside the course as well as in relation to the content of studies. Through a process that has involved re-reviewing years of data and previously published materials on the course, we have discovered a new conceptualization that coincides with the two unique academic traditions that underlie the course design: humanistic (or person-centered) education (Rogers, 1969) and classroom learning communities (Bielaczyc, Kapur, & Collins, 2013). In our presentation, we show the theory, design, and empirical findings of what we call 'humanistic learning communities'.

Theory and design

Our claim in this paper is that transformational learning, which involves an interplay of knowing, doing, and being, can be enacted through the person- and idea-centered activities. Person-centeredness is based on the goals of self-actualization within the context of a person's life experiences. To best realize these goals, a person must be given unconditional positive regard and the opportunity to explore questions about their life either in one-to-one relationships or in groups (Rogers, 1969). Idea-centeredness is based on the goals of advancing knowledge, modeled after the advance criterion of the scientific enterprise. Realizing these goals involves students inquiring about topics that interest them and taking collective responsibility over community knowledge (Scardamalia & Bereiter, 2006). These centers, each from respective academic traditions, together cover the knowing, doing, and being of broad views of learning (Herrenkohl & Mertl, 2010). Accordingly, our course design balances person- and idea-centered activities nearly equally throughout the semester (Figure 1).

Example findings

Abby's (pseudonym) transformative learning involved making a key shift in her ideas about learning when she recognized the importance of the process of learning. Her product orientation was found in her professional life experiences and identity, where she was given tasks to complete individually, competed against others, and was measured based on her output. Thus, it was fitting that at the start of the semester she questioned why she should learn from others instead of listening to the instructor lecture. She experienced discomfort with the expansive activities involved while participating in the learning community. In a series of activities that were central in her transformation, her knowing, doing, and being were all at play.

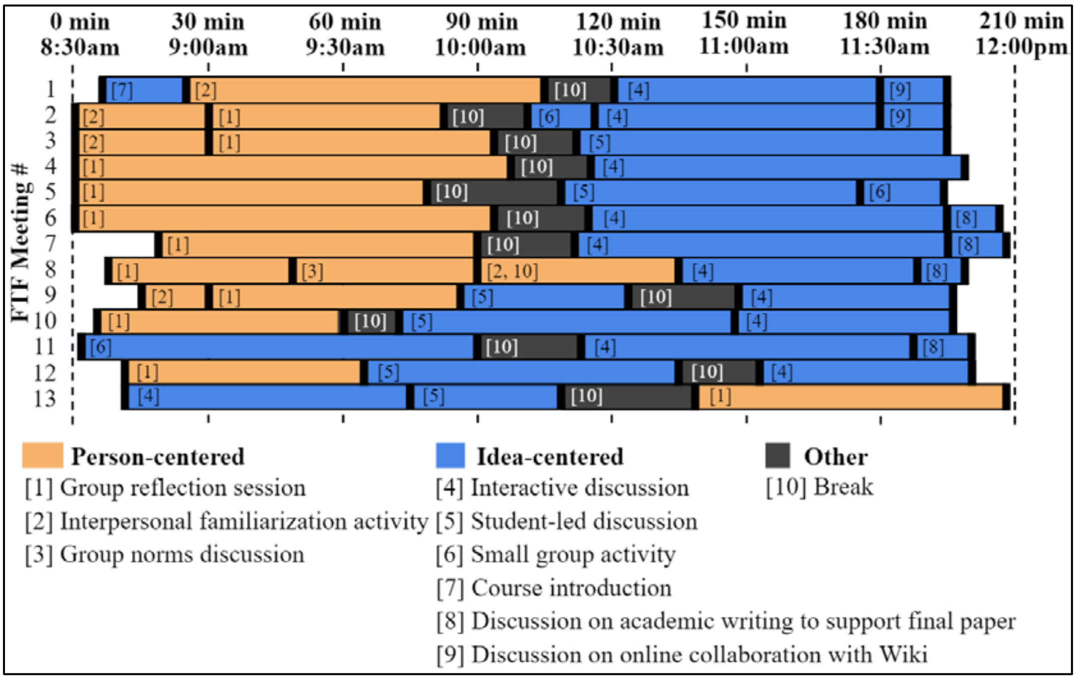

Figure 1. The balance between idea- and person-centered activities within CATELT (2011-2012).

Significance

This research makes a contribution to both learning theory and practice. The theoretical contribution is in attending to humanistic education and understanding its role in relation to idea-centered views which have become quite popular (Bielaczyc, Kapur, & Collins, 2013). On practice, the prominence given to person-centered activities is an unusual design. The purpose of giving so much time for the person-centeredness is based on our serious belief in the educational principles of Carl Rogers, where the person is accepted unconditionally and is given a fertile space to grow through their exploration of self through the other. It is in this person-centered way that we view the learning community, and why we feel it is necessary and appropriate to distinguish it from other learning communities with the 'humanistic learning community' label.

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An Emotion Awareness Tool for the Sharing of Emotions: What Impact on Computer-Supported Collaborative Processes?

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Abstract: There is a large consensus on a significant role of emotions in individual and collaborative settings. In this context, emotion awareness tools (EAT) have been developed to promote the sharing of emotions during computer-mediated collaboration. In this study, we explore whether and how an EAT impacts collaborative processes, and whether there is a gender effect. Results showed that the EAT was beneficial to mutual modeling processes but we found also that men exchanged more verbal acts aiming at improving the relational climate but expressed less divergent opinions with the EAT, which is not the case in women.

Introduction

There is a strong empirical evidence that emotions have an influence on problem solving and learning as they affect attention, motivation, use of strategies and self-regulation processes (Pekrun, 2014). In collaborative working/learning environments, emotions are recognized as playing a role in mutual modeling (Molinari, Sangin, Dillenbourg, & Nüssli, 2009), relationship (Andriessen, Baker, & Van der Puil, 2010) and performance (Eligio, Ainsworth, & Crook, 2010). However, access to emotional information may be limited in remote computer-supported collaboration. One way to increase emotion awareness during remote collaboration is to provide collaborators with emotion awareness tools (EATs). In Molinari, Chanel, Bétrancourt, Pun, & Bozelle (2013), an EAT has been developed offering the possibility to share emotions during collaboration. In the EAT condition, a positive relation between emotion modeling and the time spent building on the partner's contributions (transactivity) was found. However, we found also that the effect of the EAT on transactivity was confined to women, whereas the EAT tended to reduce transactivity in men. Woolley, Chabris, Pentland, Hashmi, & Malone (2010) also showed that the number of women in a group is a significant predictor of the group collective intelligence because women score higher than men in social sensitivity measures, i.e. the ability to understand social cues. The EAT could therefore have a beneficial effect in women, possibly by compensating the lack of emotional information. By contrast, men could be disturbed by this kind of emotional sharing. In the present study, verbal interaction data from Molinari et al. (2013) were analyzed to evaluate further whether and how the EAT impacts actual collaborative processes, and whether this effect varies depending on gender.

Method

The sample consisted of 38 participants working in 19 same-gender dyads (6 women dyads, 5 men dyads in the EAT condition; 6 women dyads, 2 men dyads in the control condition). All dyads performed a remote collaborative design task. Dyad members were asked to create together a slogan against violence in school using an argument graph tool. A coding scheme was designed to analyze both socio-cognitive and socio-relational processes. It was composed of 26 sub-categories of collaborative processes group in 7 categories: (1) *Outside Activity,* (2) *Social Relation,* (3) *Interaction Management*, (4) *Information Sharing*, (5) *Task Management*, (6) *Transactivity* and (7) *Tool Discourse*. A full description is available at the following address: https://goo.gl/lj93kl. For each dyad, the whole verbal interaction content was first transcribed with the ELAN software. Two independent coders applied the coding scheme. The inter-coder reliability of Cohen's kappa was equal to 0.47 (moderate agreement).

Results

The results showed a positive effect of the EAT on the *Use social convention*, *Give self-information*, and *Elicit-partner information* variables. More precisely, the rate of use was higher in the EAT condition than in the control condition for *Use social convention* (EAT: $M = 0.96$, $SD = 0.56$; Control: $M = 0.52$, $SD = 0.60$; $F(1, 34) = 4.75$, $p = .003$, $\eta^2 = 0.12$), *Give self-information* (EAT: $M = 4.71$, $SD = 2.54$; Control: $M = 2.89$, $SD = 2.24$; $F(1, 34) =$

6.92, p = .012, $\eta^2 = 0.16$), and *Elicit-partner information* (EAT: M = 0.81, SD = 0.12; control: M = 0.36, SD = 0.57; $F(1, 34) = 5.43$, p = .002, $\eta^2 = 0.13$). The EAT had a negative effect for *Coordinate teamwork*, with a higher rate in the control condition (M = 2.89, SD = 1.28) than in the EAT condition (M = 2.04, SD = 1.59), $F(1, 34)$ = 3.85, p = .057, $\eta^2 = 0.10$. There was a significant EAT by Gender interaction for the *Relax atmosphere* variable ($F(1, 34) = 6.59$, p = .014, $\eta^2 = 0.16$) and for the *Give opinion against* variable ($F(1, 34) = 7.65$, p = 0.009, η^2 = 0.18) (Figure 1). Men produced more *Relax atmosphere* acts in the EAT condition (M= 6.35) than in the control condition (M= 0.92), whereas there was no significant difference between the EAT condition (M= 4.75) and the control condition (M= 4.20) for women. Men produced more *Give opinion against* acts in the control condition (M = 3.43) than in the EAT condition (M=0.92), whereas there was no significant difference between the EAT condition (M=1.52) and the control condition (M=1.55) for women.

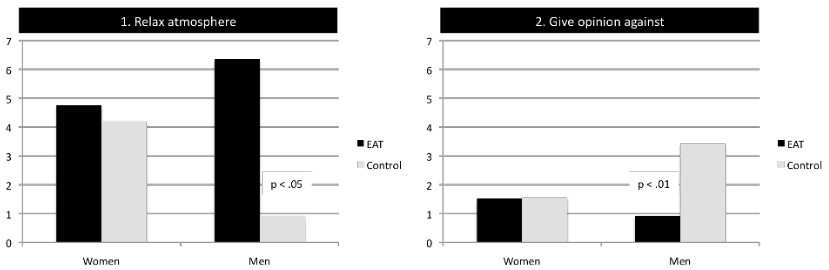

Figure 1. Interaction between EAT and Gender for *Relax Atmosphere* and *Give Opinion Against.*

Discussion and conclusion

First, we found that the EAT encouraged to be more engaged in the mutual modeling process, i.e. the process of building and updating a mental model of the other. That could be explained by an increase of the receptivity to each other driven by emotion communication during interaction. Second, there was an EAT by gender interaction for two process variables, i.e. *Relax atmosphere* and *Give opinion against*; the effect of the EAT on these collaborative acts was observed only for men. The EAT encouraged men to reduce the emotional tension during interaction by producing verbal acts designed to relax atmosphere and by avoiding socio-cognitive conflicts. By focusing on emotions, men would be more inclined to build and maintain a positive climate that could be in opposition with a greater propensity to initiate and conduct negotiations (Small, Gelfand, Babcock, & Gettman, 2007). There is a need to be cautious with these results because the total number of women dyads (N = 12) was higher than the total number of men dyads (N = 7) and the number of men dyads in the control condition was really low (N = 2) compared to the number of men dyads in the EAT condition (N = 5). Despite this limitation, the results described in this paper contribute to a better understanding of how the sharing of emotions during computer-mediated collaboration shapes the way people interact with each other.

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In Search of Helpful Group Awareness Metrics in Closed-Type Formative Assessment Tools

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Abstract: For 4 weeks, a total of 91 sophomore students started their classes with a short multiple-choice quiz. The students had to answer the quiz individually, view feedback on class activity, revise their initial answers, and discuss the correct answers with the teacher. The percentage of students that selected each question choice and their self-reported confidence and preparation were the three metrics included in the feedback. Results showed that students were relying mainly on the percentage metric. However, statistical analysis also revealed a significant main effect for confidence and preparation metrics in questions where the percentage metric was ambiguous (i.e., several choices with high percentages).

Keywords: Group awareness, formative assessment, quiz, confidence, preparation.

Introduction

The study focuses on the multiple-choice quiz as a formative assessment tool. When supported by technology, formative assessment can include immediate, personalized, and customizable feedback (Sosa, Berger, Saw, & Mary, 2011) and provide additional opportunities to the learner for self-reflection and self-assessment (Bransford, Brown, & Cocking, 2000; Kleitman & Costa, 2014). Feedback could be based both on teacher's/designer's previously submitted input and on information on fellow students' activity. Bodemer (2011) suggested that comparability should be a crucial part of group awareness tools, noting that allowing students to compare their knowledge with that of peers' can significantly enhance learning. The literature abounds with studies on the benefits of supporting group awareness and the characteristics of group awareness tools (e.g., Lin, Mai, & Lai, 2015, for a review). Despite this, the feedback the student receives in quizzes stays on the surface, focusing only on the percentage of students under each choice in the quiz. Although useful, this metric lacks any additional qualitative information that could be useful for the students in self-assessment. The current study discusses the impact of two additional metrics, alongside the percentage, that could better depict the class knowledge, namely the level of preparation (i.e., study effort) and the level of confidence (i.e., how sure the students are that their answers are correct). The preparation metric is a self-reported, subjective metric showing how prepared the students feel, just *before* they take the quiz. Confidence, on the other hand, is a metric denoting how sure the student is *after* having answered a question/quiz.

Method

A total of 91 sophomore students enrolled in the undergraduate "Business Development with Information Systems" course volunteered to participate in the study and were randomly distributed by the system into 4 groups: *Control* (27), *Confidence* (22), *Preparation* (22), and *Both* (20). The lecture material is available online a week in advance and students are expected to read it before coming into the class.

The "Self-Assessment/Group Awareness – SAGA" online quiz system was developed for this study. After logging in, students have to answer a question regarding their level of preparation for today's lesson using a 1-5 Likert scale (5: Well-prepared). Next, there is a series of 8 multiple-choice questions created by the teacher, with 4 choices each. Each question is accompanied by a question on students' confidence, using once again a 1-5 Likert scale (5: Very confident). In the revision phase that follows, students can browse through the 8 questions and have the opportunity to change their initial answers. Depending on the study condition, the system provides information about the class, next to each question choice:

- Control: the percentage of student in the class that selected each option.
- Confidence: the percentage and the average confidence score of students that selected each option.
- Preparation: the percentage and the average preparation score of students that selected each option.
- Both: the percentage, the average confidence, and the average preparation scores of students that selected each option.

After the completion of the revision phase, the students are able to see their scores and the correct answers.

For 4 consecutive weeks, students started the class by going through the three phases of the SAGA system. Students were given 10 minutes to provide their initial answers, 5 minutes to revise them, and 5 minutes to discuss correct answers with the teacher. After the fourth week, students answered a survey that recorded their opinions towards different aspects of the activity. The whole activity was individual and anonymous.

For all statistical analyses, a level of significance at .05 was chosen. Performance analysis focused only on a sub-set of 13 out of the 32 questions the students answered during the first 4 weeks. These answers were selected after the fourth week, because it was not possible to identify during the design time of the study the questions in which students would need additional feedback. Thus, the impact of the confidence and preparation feedback was analyzed only when the percentage alone could not "clearly" point at the correct option. The definition used in the study to identify these "clear" cases included three conditions that had to be true at the same time: (a) the correct choice was also the most selected, (b) the correct choice was selected by at least 50% of the students, and (c) the correct choice had a least 20 points difference from the second most selected choice.

Results

Table 1 shows student performance in the initial and the revision phase in these 13 challenging questions. Paired-samples t-test results showed that Confidence ($t[21] = 2.324$, $p = 0.030$, $d = 0.720$), Preparation ($t[24] = 2.027$, $p = 0.046$, $d = 0.630$), and Both ($t[19] = 2.979$, $p = 0.008$, $d = 0.970$) groups scores improved significantly during the revision phase, while the Control group was the only one that did not improve. Students evaluated the usefulness of the different types of feedback as: percentage ($M = 3.62$, $SD = 1.01$), confidence ($M = 3.32$, $SD = 1.20$), and preparation ($M = 2.64$, $SD = 1.43$).

Table 1: Student performance in the 13 challenging questions

	Control			Confidence			Preparation			Both		
	M	*SD*	n	M	*SD*	n	M	*SD*	n	M	*SD*	n
Initial	4.44	*(4.34)*	27	3.82	*(3.59)*	22	5.27	*(3.98)*	22	4.40	*(2.87)*	20
Revision	4.00	*(4.29)*	27	4.90	*(3.00)*	22	6.36	*(4.22)*	22	6.60	*(3.73)*	20

Discussion and conclusions

The percentage metric is objective, easily understood, and adequately good in indicating the correct answer (19/32 in this study). However, it does not carry any information about the people that are behind the figures. Confidence and preparation, on the other hand, provide qualitative information on the participants, but they both rely on participants' metacognitive level and their ability to accurately assess their preparation and confidence levels. The study provided preliminary evidence on the reliability and helpfulness of different metrics that could better support cognitive group awareness in the confined context of individual multiple-choice quizzes. The findings for the designers of such tools are clear and suggest that metrics that would better describe the participants are easy to use and have a significant effect on students' performance.

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Adding Time to Social Networks: A New Perspective on Using Learning Analytics for Learning Environment Design

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Abstract: This study shows dynamic network analysis extracts additional insights into student-teacher interactions in learning environments from large-scale behavior data. Taking a design research perspective, this study examines how 323 students and 9 teachers read each other's written compositions in an online literacy environment. The analysis reveals longitudinal differences in the social dynamics between students and teachers in different classrooms demonstrates how inclusion of teachers completes the picture of learning design and implementation in CSCL research.

Keywords: dynamic social network analysis, learning environment design, design-based research, classroom interaction

Introduction

Social network analysis (SNA) is especially relevant in CSCL research. It provides both easily interpretable visualizations of the interactions between learners with sociograms and quantitative measures of the different roles learners play and the nature of social interactions (Hernandéz-García et al., 2015). However, SNA provides merely a fragmented snapshot or an aggregated view of the social interactions (Kolaczyk, 2009), without examining how these interactions change over time: new relationships could be established, old connections might dissolve, and the power dynamics could change. With time as an additional dimension, dynamic/temporal social networks can capture these changes, which helps us understand more about how socially-enabled learning environments work.

The purpose of this study is to explore whether the descriptive analysis of dynamic/temporal social networks can be effective in extracting useful insights on the use of one specific feature of an integrated online literacy environment called Udio. With the Universal Design of Learning (UDL; Rose, 2000) as its guideline, Udio is an online literacy platform designed to longitudinally improve the reading and writing skills of all learners with rich supports, such as built-in dictionaries and Text-to-Speech (TTS) Engines. To support the development of writing skills, Udio allows users to create "projects," short texts combining snippets of texts and images from Udio articles as well as writings and drawings based on users' own understanding of the texts, which can be shared with other Udio users from the same classroom. The focus of this study is to discover the extent to which the projects were read by the others after being published by Udio users. It assumes a design-based research (DBR) perspective (Barab, 2014; Barab & Squire, 2004) and uses the information gained through dynamic network analysis to reflect on the design of Udio. The research questions are:

- Was the "Read Project" function frequently used by students and teachers in Udio?
- How did the usage of the "Read Project" function change over time?
- How did the usage of the "Read Project" function over time vary across different classrooms?

Dynamic Social Network Analysis

323 students and 9 teachers from 7 middle schools across the US consented to participate in the study in the 2014-15 academic year. Although some demographic information is missing, this sample represents a fairly heterogeneous group with more male (190) than female (120) students. Approximately 81 students have IEP statuses, 68 are ELLs, and 211 are on Free or Reduced Lunch Plans.

Udio's event logs, which store over 600,000 user behavioral data logged between November 2014 and July 2015, were used to construct the dynamic social network. The network is visualized in Figure 1. Each node in the network represents either a student or a teacher in Udio. The color of the node indicates which class a Udio user belongs to, and only the teachers are labeled. Each edge is defined as the direction and frequency of the "Read Project" behavior: if User A read B's project, an edge (arrow) is defined pointing from A to B, with its weight (thickness) being the "frequency" of such visits taking place. The "frequency" of visits is defined as numbers of "valid clicks", visits lasting more than 20 seconds, a reasonable amount of time for a typical middle school students in the sample to read most projects. Noisy records such as visits originating from refreshing the browser and visits to each user's own projects (loops) were excluded. Each edge, upon creation, stays in the network, while each further visit between the same source-target pair adds to the weights of the edges.

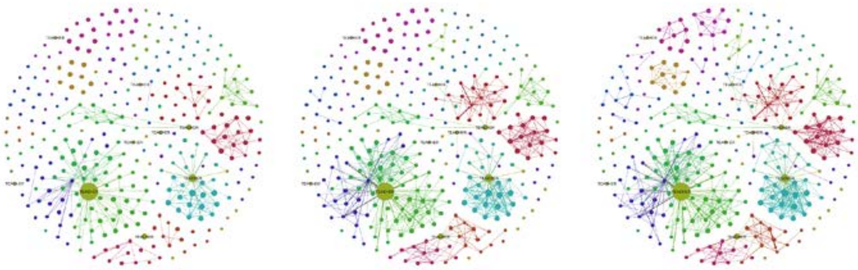

Figure 1. Visualization of overall network as of January, March, and May 2015.

Results

The first two research questions can be answered with Figure 1. Although the overall network is sparse with low density and about 20% disconnected nodes, the out-degree distribution suggests highly varied levels of use across users and different classrooms, and assortativity coefficients reveal no specical patterns for IEP or ELL students. Temporal changes revealed "late-comers" – some classes did not start using this function until late in the Spring semester. Most interestingly, teachers played completely different roles in this network: one teacher read other students' projects close over 400 times, while three others did not use this function at all.

To answer the third research question, I chose three largest components of the overall network, named them Classes 1-3, visualized them individually, and examined the growth of student-student, teacher-student, and student-teacher project visits over time (Figure 2). Class 1 is a typical star-shape network with the teacher playing a central role. In this class, the teacher visited students' projects more than all student-student project visits combined. The growth of student-student visits also corresponds with teacher-students, suggesting a usage pattern prompted by the teacher. In Classes 2 and 3, however, project visits seem to be more voluntary, and the growth is steadier than that in Class 1. In all three classes, the common pattern follows an initial surge succeeded by a level-off in the Spring semester and another surge in June 2015.

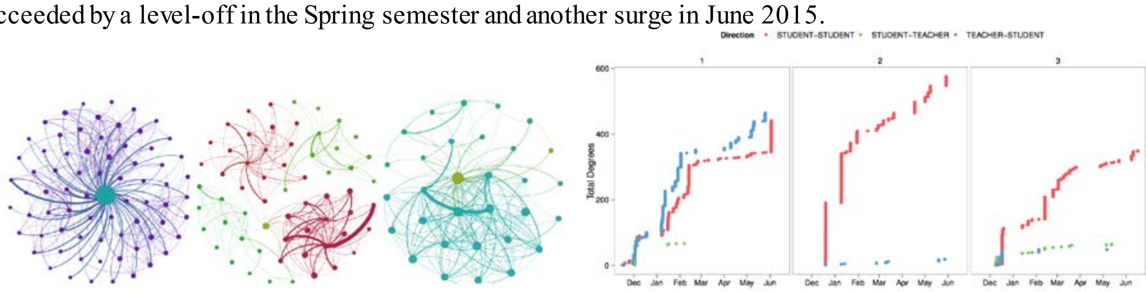

Figure 2. Visualization and growth of out-degrees in Classes 1-3.

Conclusion

Dynamic SNA reveals not only topological but also temporal patterns in how the individuals in the network interact with each other. Specifically, this study highlights the key role teachers play in enacting the design of computer-supported collaborative learning environments, which enables learning environment designers to ask further questions about what perceptual and design factors led to these differences, to what extent these differences should be allowed, and the effects of these differences on learning. This suggests one analytical approach to large-scale behavior data that can be used to improve learning environment design.

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Promoting Equity and Access in Public Libraries' Computer-Supported Youth Programming

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Abstract: This poster documents public youth librarians' efforts to incorporate digital and networked technologies into programming and demonstrates the roles that librarians can play in creating CSCL environments. Using connected learning as a framework, we identified challenges faced by youth librarians in their efforts to create equitable computer-supported learning environments.

Introduction

Library-based learning environments are increasingly supported by computers and other networked technologies. Unfortunately, well-resourced libraries in affluent neighborhoods are typically best positioned to offer rich computer-supported learning experiences (Braun, Hartman, Hughes-Hassell, & Kumasi, 2014). To address this challenge, we conducted interviews and focus groups with youth librarians, asking them to describe their youth programs, their use of technology, and the struggles they face in their efforts to create equitable, inclusive computer-supported learning environments.

Theoretical context

Our work is theoretically informed by Ito et al.'s (2013) connected learning framework, which promotes connections across three learning spheres. *Academically oriented* learning helps young people align their learning activities with future ambitions. When learning is *interest-driven*, young people are motivated to acquire knowledge in areas of personal interest (Barron, 2006). Learning that is *peer-supported* allows young people to interact with and learn from others with shared interests. Connected learning environments also embody three core properties. *Production-centered* environments offer activities and spaces that allow for experimentation, remixing, and design. When young people work cross-generationally with a *shared purpose*, their learning becomes collaborative and embedded in communities of practice (Lave & Wenger, 1991). Finally, *openly networked* infrastructures such as online communities are used to provide support and collaboration across diverse contexts.

The current study

The following research questions guided our investigation:

RQ1: How are public youth librarians across the country currently incorporating technology into their youth programming?

RQ2: What challenges do public youth librarians face with respect to creating equitable computer-supported learning environments?

Method

Context

This study is embedded within a larger initiative, ConnectedLib, which aims to develop a suite of professional development resources to build public librarians' capacity to leverage digital media and connected learning principles. This three-year study is jointly conducted by the University of Washington and the University of Maryland, and three library partners: Providence Public Library, Seattle Public Library, and Kitsap Regional Library.

Participants

We conducted interviews with 66 youth librarians working in public libraries. We also organized three focus groups with 26 youth librarians during the Young Adult Library Services Association's (YALSA) Symposium in November 2015, American Library Association's (ALA) Midwinter Meeting in January 2016, and the

Maryland/Delaware Library Association Conference in May 2016. Our sample represents 41 states and the District of Columbia, and rural, suburban, and urban libraries from all regions of the United States.

Data analysis

Using thematic analysis (Boyatzis, 1998), we developed a coding scheme that aligned with Ito et al.'s (2013) connected learning framework and our research questions, and employed a joint iterative process of collaborative discussion among researchers (Smagorinsky, 2008). All researchers discussed the codes applied and agreed on definitions, discussing areas of disagreement until reaching consensus on all coded excerpts. We repeated this process three times until achieving satisfactory levels of reliability (average Kappa statistic for final round of coding = .98, range = 0.76–1.00) (Landis & Koch, 1977).

Results and discussion

Technology use is ubiquitous in library youth programming; 98% of librarians we interviewed described some form of technology use, such as providing production-centered activities or free access to digital tools and equipment. Several libraries are engaged in efforts to offer technology that supports youth's interests in music, gaming, and design. Some librarians described more passive uses of technology, like providing access to digital and networked technologies. Much of this technology use exemplifies aspects of connected learning, particularly *openly networked* and *production-centered* experience (like a learn-to-DJ program).

We uncovered three main challenges that public youth librarians face. Librarians find it difficult to implement equitable, openly networked infrastructures because they often don't have the digital tools they need due to library policy. Providing experiences that go beyond simply introducing new technologies is also challenging for non-dominant youth, since librarians were often unsure about how to design or facilitate technology-focused or -infused programming. This uncertainty bled into their relationships with youth patrons, leading to concerns about how to serve as effective digital media mentors.

Our findings point to potential strategies to support connected learning in ways that address equity and access. First, libraries need support in providing technological access, especially for non-dominant youth. (Seattle Public Library's program to lend Wi-Fi hotspots is one promising strategy.) Library administration must also address restrictive social media policies. Finally, librarian training should expand into areas like mentoring, design thinking, and 21st century skills, with a focus on reaching out to non-dominant youth.

Limitations, future directions, and conclusions

The diversity of our sample is a strength of this study, however, since participation was voluntary, our sample may consist primarily of librarians who have an interest in connected learning and CSCL environments. In the next phase of the study, we will develop a suite of professional development resources aimed at enhancing librarians' capacity to leverage digital media and connected learning principles, vetting preliminary content through participatory design sessions with youth librarians. This research is a first step in understanding how youth librarians are incorporating the connected learning framework into the planning and creation of CSCL environments and points to specific needs, including collaboration between researchers and librarians to develop connected learning environments; and training that provides assistance with navigating technology, mentoring, and connected learning principles.

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Exploring Ways of Contributing to Math Talk in a Knowledge Building Community

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Abstract: This study explores "Ways of Contributing" to mathematics discourse in a Knowledge Building community. The discourse of Grade two students studying geometry was analyzed to identify contribution patterns in both face-to-face and computer mediated discourse. The discussion focuses on the nature and diversity of contributions to knowledge advancement in these different contexts.

Introduction

"Math Talk is a style of discussion in the classroom that allows students to learn through discourse." (Mountz, 2011:3) Griffen et al. (2013) found that 75% of instructional lesson time was used to teach algorithms while only 19% focused on conceptual understanding. Knowledge Building (Scardamalia & Bereiter, 2003) is defined as "the production & continual improvement of knowledge of value to a community" (Scardamalia & Bereiter, 2003: p. 1370). Supporting math talk through Knowledge Building should result in rich, inclusive, & purposeful discourse. The goal of the current study is to engage students in constructing mathematical explanations, not simply sharing their answers, but to increase conceptual understanding in geometry. Chuy, Resendes, &Scardamalia (2010) developed a Ways of Contributing analysis that has been used to assess explanation seeking dialogue & to determine if elementary school students are constructing coherent explanations (Resendes, 2014). The ways of contributing that they identify are important to the Knowledge Building community as they frame contributions that allow discourse to advance. The current study will be the first to explore within the context of mathematics, & the extent to which students articulate ideas, learn from one another, are engaged as active agents with responsibility & agency, innovative ideas, & deeper conceptual understanding, which can contribute to deep mathematical understandings & initiate reflective ideas.

Methods and analysis

Participants included 22 grade two students (8-9 years) attending a primary school in downtown Toronto. During each class students engaged in face-to-face classroom discourse, with students generating questions, thoughts, & proposing answers in person. This was followed by computer-mediated discourse using Knowledge Forum technology, with all notes typed or dictated & available as text on laptop or iPad. They engaged in both forms of discourse twice a week for two months, corresponding to the full length of a Geometry unit, with each period lasting 60 minutes (half hour Knowledge Building Circle, half-hour Knowledge Forum). The data for the current study includes student dialogue for the duration of the Geometry Unit; 316 speaking turns of student Knowledge Building Circle dialogue&306 Knowledge Forum online notes. In addition, the teacher contributed 160 lines of dialogue during the knowledge building circle, but made no contribution to Knowledge Forum notes. While the teacher was present during the knowledge building circle, her discourse is excluded from this study. Six categories were included from the (Chuy, Resendes & Scardamalia, 2010). (Coding Schema as seen in Figure 1)

Results

As depicted in figure one, students were engaged in the full range of discourse moves associated with the Ways of Contributing framework. Preliminary results indicate that students did more theorizing on Knowledge Forum than in the knowledge Building circle—they were coded as "Theorizing" almost twice as much in Knowledge Forum. This finding is interesting as the teacher did not contribute to the Knowledge Forum platform. Figure two demonstrates the percentages of each category per each medium. Within the category of supporting discussion, the usage of student math talk examples may not have included specific math concepts directly. An example of student discourse is the following: "Yes because it pops up." While this sentence does not allude to specific math talks, it supports a spatial awareness understanding of three-dimensional shapes, in which furthers the contribution of the community& of the individual. While the contribution falls under supporting discussion, it still adds value to the collective understanding of Geometry. One interpretation would be that the student's contributions are affected through modelling the contribution styles of the role of the teacher, & play a dominate role in shaping student's ways of contribution. Furthermore, by having the teacher provide more "thought provoking questions", it led the students to then theorize after their conversations within the knowledge building circle, & post them on Knowledge Forum.

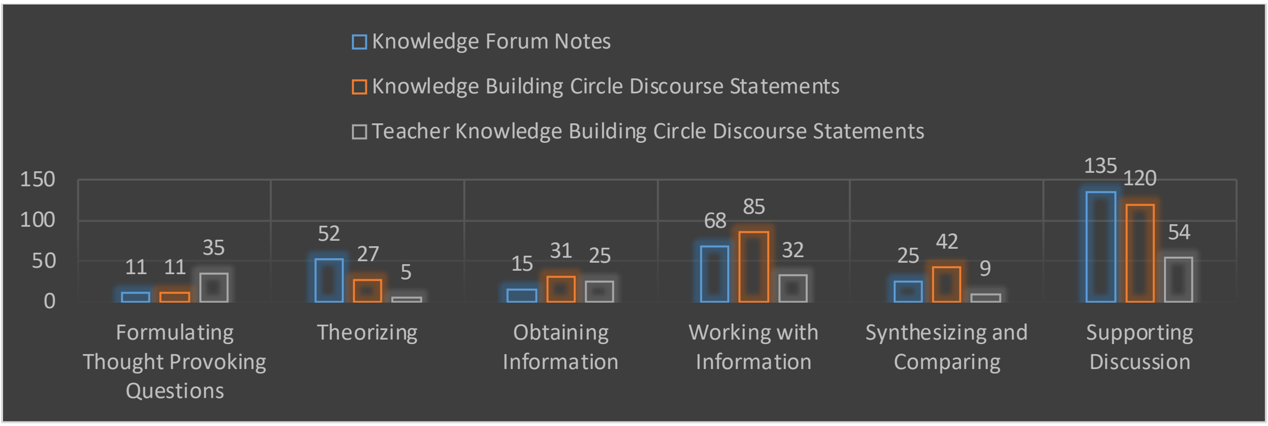

Figure 1. Frequency(number) of Knowledge Forum Notes & Knowledge Building Discourse statements.

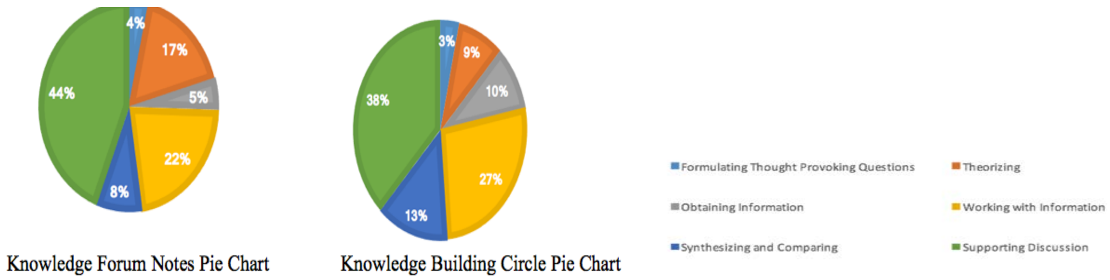

Figure 2. Knowledge Forum Notes Ways of Contribution Pie Chart Percentages.

Further analyses are needed to understand how these mathematical concepts are introduced to the Knowledge Building community. For example, what is the proportion of new math concepts introduced by the student are teacher versus by students? While this study still is in its analysis phase, we hope to demonstrate that students engaged in Knowledge Building ways of contribution, are exposed to diverse math ideas & constructively use new math concepts to advance their community knowledge.

Implications

This study fits directly with the conference theme of “Access & equity in high-quality knowledge," due to the ideal students access to accessible technology & methods to share their learning in a community setting, accommodating various learning needs & abilities. These analyses are to be addressed more in the final poster. Multiple valid interpretations allow for students to have discussions around a problem set, & will engage students to be inquisitive, curious & to compare one another's explanations to push their thoughts further than ever before. To conclude this poster is only a starting analysis of a larger research project, & we hope the continued research will help educators increase knowledge creation within the discipline of Mathematics.

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Brokering Collaborations Among Children for Equity

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Abstract: This paper presents our work exploring the design of embodied technologies to mediate collaborative interactions among kindergarten-aged children, who come from diverse cultural and linguistic backgrounds. This mediation will focus on helping children develop positive learner identities and equitable friendship in a techno-socio triad of a robot, native English-speaking children, and English-learning children. Using design-based research, our theory-driven designs will be refined through ethnographic observations and interviews in iterative cycles.

Keywords: Educational robots, Social Robotics, Diversity and Inclusion, ESL, Elementary children

Major issues addressed

Although the growing number of language minority students in public education is a trend worldwide, the number of English language learners (ELLs) in the United States has almost tripled over the last decades. The National Assessment of Educational Progress results indicate an achievement gap and a very flat trajectory for lower-performing students, especially ELLs. Because of their developing English skills, ELLs consistently score lower than their native English-speaking peers in all subject areas measured nationally. More problematically, deficit thinking and marginalization prevalent in the classroom have taken a toll on ELLs' identity and learning. They are often viewed by educators and classmates as having deficits because they come from families, cultures, and language groups considered less knowledgeable and supportive than the American mainstream (Valencia, 2010). They are also viewed as *not* being able to contribute to the classroom due to their developing English skills and, therefore, less competent and capable than their native English-speaking peers.

Schools and classrooms should be learning communities, where students are encouraged to collaborate with peers and teachers for the purpose of academic success. Those deficit perspectives regularly position ELLs as outsiders to the mainstream learning community; ELLs learn to identify themselves with marginalized communities (Marx & Saavedra, 2014). The high dropout rate for ELLs in US schools is likely tied to this marginalization from the mainstream learning communities of schools and classrooms (Gándara, 2010). These students are less likely to see the availability of mainstream paths to success through schooling. This identification with marginalization can start as early as preschool and becomes more entrenched as children grow older. In fact, even when ELLs reach desired English proficiency levels in later school years, the achievement gap does not improve. Rather, the dropout rates of ELLs increase as they age.

The early school years are an especially critical period when children are first exposed to academic English and also when they become aware of themselves in relation to peers and begin comparing their performance to that of their peers in the classroom. There is an urgent need for early intervention to disrupt such deficit positioning and reposition English learning children as valuable contributors to the classroom so that they can develop positive identities as learners. Finding effective ways to support ELL achievement seems to be a priority nationally; however, supporting their positive identity development may be more urgent than or, at least as important as, supporting their academic skill development.

We view ELLs as a *culturally and linguistically diverse (CLD)* group who can enrich the mainstream school culture with their cultural and linguistic assets (Vasquez et al., 2011). We envision technology that serves as a cultural broker, helping all learners to expand the boundaries of their intellectual, social, and cultural communities and feel included as valuable participants in a learning community (Gutierrez, Rymes, & Larson, 1995; Murata, 2013). In this study, we explore the creation of a small socio-technical learning community for CLD children that recognizes cultural and linguistic diversity as an asset and provides an opportunity for them to share their cultural resources, including their home language and family stories. We understand that young children are very likely to develop social relationships with animated characters, virtual pets, and robots (Breazeal, 2002; Kim, 2013). We build on this understanding by introducing a robot that can mediate the interactions between English-speaking and English-learning children in ways that invite both to learn from each other and to learn to interact in equitable ways.

Theoretical and methodological approaches

Our study centers on the development of robot-mediated interaction activities in an iterative cycle of design, development, and testing. The questions for our design research include i) *What does it take to design robot-mediated collaborative interactions to support children's development?* and ii) *How do children's identities and learning develop as they participate in the collaboration?* Our iterative development processes will be orchestrated with two types of data collection: ethnographic observations in a natural classroom and interviews with the children, parents, and teachers. Children's interactions with the system will be recorded as supplementary data.

We take into consideration the rhetorical and socio-cultural perspectives of communication theories as we develop a theoretical model to guide initial scripts for the robot's mediating utterances (Bahktin, 1987). In particular, we use the Wizard of Oz method, in which the robot utterances are added, corrected, and refined as we observe children's participations in the interactive triad. The product of the study is a corpus of interactive utterances of the robot, which can be used by other researchers developing similar technologies to mediate collaborations.

The design of collaborative activities for children is grounded in the literature in culturally responsive pedagogy, developmentally appropriate pedagogy, and second language acquisition, with the goal of facilitating children's positive identity formation. Culturally responsive pedagogy asserts that cultural characteristics should be respected throughout curricula (Ladson-Billings, 2009). Developmentally, around kindergarten age, children improve in fine and gross motor skills and like to engage in fantasy play. Language acquisition is the process of learning a language naturally through repeatedly participating in social interaction. The core ideas from these theories frame six focal strategies that guide the initial design of the robot-mediated interactions: i) learning in play, ii) multiple channels for interaction, iii) fantasy storyline, iv) autonomy support, v) from the familiar to the new, and vi) repeated participation (Kim & Smith, 2017).

Significance of the work

This study explores a new way of using technology as a cultural broker and sheds light on how artificial beings can be designed to mediate the equitable collaborative interactions of young children from diverse cultural and linguistic backgrounds, whether they take the shape of pedagogical agents (on-screen animated characters), embodied robots, or holograms. Also, the invitational rhetoric to be developed will likely allow CLD learners to feel included and respected in the socio-technical learning community. It may also facilitate equitable relationship building among students. Offering such a supportive learning community can lead all students to feel fully engaged in their learning, a critical harbinger of educational success.

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Capturing and Visualizing: Classroom Analytics for Physical and Digital Collaborative Learning Processes

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Abstract: Teachers are increasingly expected to "blend" face-to-face practice with online learning. Multimodal data capture and analytic methods are needed to understand the activity of learners using technologies in the classroom, and to provide meaningful information to teachers to enact computer-supported collaborative learning design. We present the design and deployment of a classroom observation system combining data from face-to-face classroom spaces and online learning environments to generate meaningful representations of technologically supported collaborative teaching and learning.

Keywords: multimodal data, learning analytics, classroom observation, video observation

Introduction and background

Current methods of classroom research have struggled to meaningfully capture the longitudinal and complex nature of computer supported collaborative learning processes (CSCL). Integrating digital devices and online tools into classroom practice asks teachers to "blend" their traditional face-to-face practice with learning in digital online places (Sharples, 2013). In this context it becomes increasingly challenging to understand learner activity in order to inform assessment and design. Multimodal data capture and analytic methods are needed to process a wider range of classroom data to understand CSCL. Fortunately, there have been vast improvements in existing data collection tools to capture audio and video in classroom spaces (Blikstein, 2013; Thompson, Howard, Yang, & Ma, 2016). Teachers also need tools that meaningfully communicate this activity, to make informed decisions about teaching, assessment and design. We present the initial stages of the design and deployment of a classroom observation system that collects data from the face-to-face classroom and online learning environments to generate meaningful representations of technologically supported collaborative teaching and learning. The objective is to help understand the conditions in which CSCL can succeed through the use of appropriate video mining techniques for interaction pattern identification and discussion of implications for the design of CSCL activities for primary aged students (6-12 years).

We argue that to capture learning in the contemporary classroom, it is necessary to design observation methods that can capture the longitudinal nature of learning in both physical and digital spaces, and meaningfully communicate results to teachers and schools. We have the potential to identify more moments of learning in contexts from which a variety of data sources such as speech, video, eye tracking, are available (Ochoa & Worsley, 2016). Blikstein (2013) identified a range of new collection tools that can be used in face-to-face teaching spaces to collect multimodal data about learning, such as wearable cameras, geolocation sensors and eye tracking. New aspects like body movement or posture can be used to gain better insight on learning experiences (Raca, Tormey, & Dillenbourg, 2016). By bringing these together, it is possible to give insight into cognitive processes and specific pedagogies (Berland, Baker, & Blikstein, 2014; Blikstein, 2013), such as collaboration or use of a specific digital technology. However, the presence of these data sources also presents significant challenges to be combined and derive meaningfully representations of learning to inform teaching, assessment and design. The solution presented here collects data through a low-disturbance classroom video observation system combined with an agent-based computer logging from online learning environments and classroom artefacts. The system is designed to capture important element of learning, such as individual behaviors, but also interaction among learners, the teacher, resources and movement in the learning space.

Methods

The aim of the observation system is to capture physical learning activity for extended periods of time with low-disturbance methods to reduce interference with the teachers and learners who are the subjects of this research. The observation system includes cameras, a networked base station, and a digital audio recording system. The system also contains an application that makes the recorded video accessible through a mobile app and a webpage. A two-month pilot study was conducted to test the system in two learning environments focusing on student interactions during a collaborative task. Data were collected in multiple learning situations. The accuracy of optical flow (OP) and Hue Saturation Value (HSV) tracking algorithms were tested on four videos from the classroom video data. The algorithms were applied to the videos and the OP-based method outperformed the HSV in all four cases, with the OP algorithm achieving 75.41% tracking CDR accuracy on average, much higher than the HSV algorithm (12.56%). The OP method was applied to two learning situations: an informal, after school STEM Studio, and a formal classroom.

Results and discussion

Visualizations of the motion detection data allows us to understand the activity of teachers and students in relation to CSCL. Considering the teacher is a core member of the group that connects these individuals, they are key to broadening our understanding of the role of their input and where it is situated in time, as another aspect of the conditions under which collaboration can succeed. Overlaying the paths of people with the location of tools and resources allows us to identify patterns and sequences of interaction. They include student-student interactions, student-teacher interactions, student-resource interactions, and student movement around the learning space. Results from the video processing reveal patterns of learner activity including interactions with peers, seeking resources, walking to additional locations, or none of these behaviors. The video processing provides visualization of different interactions and paths of movement between different types of tasks (e.g. group brainstorming or writing task). To create a complete picture of the classroom, the final data set captured by the system can be contextualised with other data such as teacher observations of students' relative persistence and engagement in learning, to determine how students are progressing (Nagy, 2016).

Conclusions and recommendations

Establishing connections between the wide variety of data sources emerging in learning scenarios offers an unprecedented opportunity to enhance our current understanding of technologically supported collaborative learning. The area of Multimodal Learning Analytics provides methods to explore how data from these heterogeneous and usually disconnected sources can be combined to substantially increase the insight into collaborative learning processes. Moreover, image processing algorithms have reached a level of maturity, which opens the possibility for a non-intrusive observation system to be deployed in a classroom, so that physical data can be combined with additional information from online platforms. These results show the potential of the system to detect detailed interaction patterns automatically using computer vision algorithms. We envisage that given such information, teachers will be better equipped to provide appropriate support for students as they prepare for CSCL tasks and develop 21st century skills. Future work in this area will explore ways to link the patterns detected in the physical space with data about students' online activity, the digital tools they use, for how long, and collaborative activity.

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Orchestration Challenges Raised by Transporting a Traditional Writing Activity Into a Web-Based Computer Supported Collaborative Language Learning Activity

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Abstract: Language teaching is dominated by traditional methodologies and teachers argue that elaborated pedagogies, such as collaborative learning, combined with innovative technologies lead to a classroom with a "complex ecosystem". Attempting to understand the causes of the appearing management issues, this paper uses the term orchestration to describe real-time management of learning processes and examines the orchestration challenges raised when transporting an individual writing activity into a Computer-Supported Collaborative Language Learning (CSCLL) one.

Keywords: CSCLL, orchestration, language learning, writing activity

Introduction

Many modern foreign language teaching methods have originated from the Communicative Language Teaching movement, which supports the use of CSCLL activities and the communication among students. Collaborative learning has been considered an effective instructional strategy and studies have shown that collaboration benefit students' learning; students feel more comfortable when interacting with peers, their negotiation skills are improved and all students participate actively (Chen, Looi, & Wen, 2011). Particularly, language learners need to use the target language to interact with each other and exchange information in social and meaningful context which allows assimilating new information into existing schemata (Domalewska, 2014).

However, the majority of CSCLL activities usually fail to incorporate rewarding collaboration mostly because teachers assume incorrectly that a technological innovation in a collaborative environment is enough to guarantee effective collaboration (Dillenbourg & Tchounikine, 2007). Besides, there are many other components that influence the learning outcome, such as the design model, its implementation as well as the assessment and scaffolding approaches (Cullen, Kullman, & Wild, 2013). Another critical point is to design appropriate learning tasks so that students engage actively (Kim, 2015).

In an effort to understand the large gap between the research proposals and their implementation, many researchers use the term orchestration to refer to how a teacher manages, in real time, multi-layered activities in a multi-constraints context (Dillenbourg, 2013). Language learning researchers have concluded that the appropriate orchestration influences greatly the outcome (Meskill & Anthony, 2007).

In this ongoing project, the main objective is to identify the orchestration problems that occurred due to the introduction of CSCLL in a traditional paper-based pedagogical activity. Particularly, the study aims to answer the following research questions: (1) What was the learning achievement of the activity in each case? (2) What was the students' perception? (3) What are the orchestration challenges that occurred in CSCLL activity?

Methodology

The participants of the study were 25 Greek students of English as a foreign language in intermediate and upper-intermediate level (aged 12-15) divided into two groups (control and experimental). The experimental group consisted of 16 students divided in 7 teams while the control group consisted of 9 students. Students of the control group were assigned to an inquiry-based writing activity in which they had to find information online and then work individually in the classroom. The members of the experimental group had to complete the same assignment working in small groups through a Virtual Learning Environment (VLE) which included a chat for communication and a wiki for the collaborative writing process.

The independent variables in the study were the treatments of the two different groups and the main dependent variable was the learning achievement; students' writing projects were assessed regarding their fluency, grammar, vocabulary range, cohesion and content and the data were analysed quantitatively. In order to study the students' perception of the collaborative learning environment, the members of the experimental group answered a questionnaire in their mother tongue and their answers were analysed quantitatively. Finally, with the use of the revised "5+3" conceptual framework for orchestration in learning technology research (Prieto, Dimitriadis, Asensio-Pérez, & Looi, 2015) the orchestration challenges that occurred during the collaborative process were identified (by observing and taking notes in real time) and the researcher's observations were qualitatively analysed.

Findings

Regarding the learning outcome, the descriptive statistics suggest that the collaborative texts achieved higher levels of fluency, grammar, vocabulary range and content but not of cohesion. A t-test on comparison of the means of the two groups was performed to detect a possible statistical significance, while a non-parametric Mann-Whitney U test confirmed the results. The difference in fluency, vocabulary range, cohesion and content is statistically significant but not in grammar. Hence, the learning outcome is overall enhanced in terms of fluency, vocabulary range and content when the activity is collaborative while the cohesion is decreased.

Students' responses in the questionnaire revealed that positive attitudes were held towards both the collaborative activity and the system used. The great majority of the students stated that their motivation was somehow increased because of the collaborative nature of the activity.

According to the revised "5+3" framework, the main themes of orchestration were divided in three categories: the entailed activities, the performing actors and background (Prieto et al., 2015). Regarding the activities there were a few management problems and the selected topic did not trigger valuable and authentic communication. With a reference to the actors, many students lacked the basic skill of searching online and needed some scaffolding before starting the inquiry process. Additionally, many students have difficulty in expressing themselves accurately in the foreign language. Regarding technology, the chat did not support an alert system and the wiki tool did not allow students to collaborate simultaneously. Finally, some orchestration background constraints appeared. Firstly, the time dedicated to the activity increased due to the implementation of CSCLL; students not only spent time to familiarize with the VLE but also to organize the activity and share responsibilities. Moreover, there was space limitation due to the capacity of the computer lab and prior planning was necessary. Also, some discipline problems occurred with students either using their mother tongue or being behind schedule and an on-the-fly change of the grouping was required due to an unexpected student's absence.

Conclusion and future work

The results of the study suggest that, despite some management problems, the students valued the collaborative activity positively. The learning outcome of the CSCLL activity was improved in many aspects. With regard to orchestration issues, the implementation of revised "5+3" framework helped us recognize the designing and management problems. Unlike other learning environments, language classrooms differ to the point that the language is not only the medium but also the target of the learning process. Consequently, many communication problems arise when the level of students' proficiency is low. Further research carried out over a longer time frame, a larger sample and a different approach with a more holistic view based on mixed methods is needed in order to better understand the potential of CSCLL in the classroom and the orchestration constraints that occur.

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Teacher Regulation of Collaborative Learning: Research Directions for Learning Analytics Dashboards

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Abstract: Learning analytics, the measurement and reporting of data about learners, has been advocated as a support tool for teacher regulation of collaborative learning. More specifically, so called Teacher Dashboards are currently being developed to support teachers. The aim of this poster is to provide a theoretical framing of Teacher Dashboards and to discuss the state of the art in this field. As such, this poster also contributes to formulating an agenda for future research.

Introduction

Teacher regulation of collaborative learning is a demanding task because of the multitude of activities and the rapid pace at which these activities occur (Van Leeuwen et al., 2015). Proper regulation requires a number of competencies from the teacher (Kaendler et al., 2015). Teachers have to structure, group students, and flexibly manage the design and ordering of collaborative activities. Within activities, teacher support should be contingent, that is, adapted to the needs of an individual student or a group of students. The core of these competencies is that teachers must constantly be aware of the activities students engage in and the progress students are making, in order to be able to make informed decisions. This is a demanding task, especially when learners have more control of the pace of their learning trajectory and thus the need for teacher to adapt their support to different learners becomes greater (Van Leeuwen et al., 2015). Maintaining an overview of student activities is highly challenging, also given that teachers' time and cognitive resources are limited.

Learning analytics (LA), the measurement and reporting of data about learners, has been advocated as a support tool for teacher regulation of collaborative learner. More specifically, LA in the form of so called Teacher Dashboards are currently being developed to support teachers (Tissenbaum et al., 2016). In this poster we aim to provide a theoretical framing of Teacher Dashboards and to discuss important questions that need to be addressed in this context. As such, this article contributes to formulating an agenda for future research.

A framework for Teacher Dashboards

To discuss the state of the art in Teacher Dashboards, a framework of LA is used and slightly adapted to provide four core questions. This framework, described by Clow (2012), represents LA as a process that consists of four steps: 1) identification of learners, 2) collection of data about the learners, 3) processing of data into metrics or analytics, and 4) design and execution of one or more interventions that have some effect on the learner. By slightly adjusting Clow's (2012) framework, namely by replacing 'Learners' with 'Teachers', the *Teacher Dashboard Cycle* originates (see Figure 1). Instead of starting with identifying the learner, the Cycle starts with identifying the goal of the teacher, and thereby the required function of the Dashboard. Subsequently, similar to Clow's LA Cycle, the questions follow what data needs to be captured and how this data should be analyzed and visualized. The last step, intervention, involves the question what the effects are of providing teachers with a Teacher Dashboard.

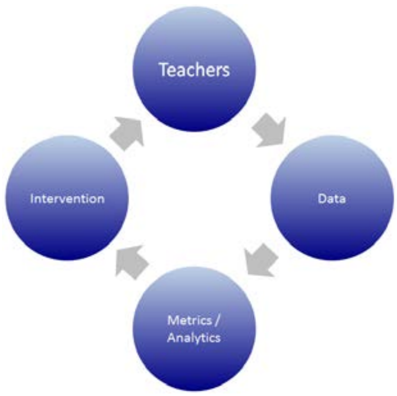

Figure 1. The Teacher Dashboard Cycle.

Discussion of four core questions

In Table 1 below, the four core questions following from the proposed *Teacher Dashboard Cycle* are displayed, along with central considerations for research related to each of Teacher Dashboards. These considerations include open questions as well as methodological challenges.

Table 1. Outline of considerations for each aspects of the Teacher Dashboard Cycle.

Topic	**1. Teachers**	**2. Data**
Question	What goals does the teacher have, and what function should the dashboard fulfill?	What data needs to be captured concerning collaborative learning?
Considerations	• Difference between dashboards that support *planning* of collaborative activities, support regulation *within* activities, and dashboards that support teacher *self-reflection* • The division of responsibility between teacher and Dashboard may be shaped differently, with differing amounts of control or interpretational freedom given to the teacher and the Dashboard	• Level of granularity of data: individual student versus data at small group level. • Type of data: data could be gathered concerning cognitive, social, affective, and physical indicators of collaboration • Question of validity of data • Possible tension between what information about collaboration a teacher finds useful, and what research points out is indicative of effective collaboration
Topic	**3. Metrics/Analytics**	**4. Intervention**
Question	How should information be visualized on the Teacher Dashboard?	What is the effect of providing teachers with a Teacher Dashboard?
Considerations	• Related to the field of human computer interaction, Teacher Dashboards should have high usability • Question of spatial placing of information: centralized versus distributed Dashboards • Question of interface design: balancing between too little and too complicated information • Possible way forward: provide *customizable* Dashboards	• Are teachers able to act on the information provided on the dashboard; is information *actionable* • Empirical studies show mixed results; possible role of teacher pedagogical beliefs and of context factors such as class size • Move towards investigating effects of Teacher Dashboards at student level, in terms of more effective collaborative learning processes and outcomes

To summarize, this poster introduces the Teacher Dashboard Cycle and outlines important questions for future research. During the CSCL2017 conference, the poster will serve as a tool to engage in discussion with the audience concerning the presented questions and issues.

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How Do K-12 In-Service Teachers Plan for Collaboration in Game-Based Lessons?

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Abstract: As game-based learning gains popularity in K-12 classrooms, it is important to consider the ways in-service educators are leveraging games for learning while also supporting collaboration. To better understand teachers' choices in this regard, the researchers collected a sample of teachers' game-based lesson plans and reflections, and coded them for themes and patterns around collaboration. Preliminary results show that teachers intentionally plan for collaboration in their development of game-based learning activities, but they need more support in selecting games that are more apt for collaboration and higher-level thinking skills.

Introduction

Collaborative game-based learning is increasingly popular in K-12 classrooms, especially because of its potential for learner groups with varying ability and skill levels. Yet, the degree to which in-service teachers plan for collaboration in game-based learning activities is unclear. The purpose of this preliminary study is to explore if and to what degree in-service K-12 teachers discuss, include, and consider their students' collaboration skills and abilities in their design of game-based lesson plans. The objective is to determine best practices for supporting teachers in facilitating students' successful collaboration skills and abilities through computer-supported learning experiences, such as those that are game-based.

Background

Strategies for planning and designing collaborative learning activities in face-to-face and online settings for K-12 learners, including those that are computer-supported, has been well-documented (e.g., Jonassen, 1999; O'Donnell & Dansereau, 1992; Palincsar & Herrenkohl, 2002). These encourage productive co-regulation, argumentation, and problem solving (Dillenbourg & Tchounikine, 2007; Palincsar & Herrenkohl, 2002). More recently, research has focused on the collaboration and cooperative aspects of game-based lessons in the K-12 classroom, showing benefits such as "positive interdependence" for intragroup experiences, and healthy competition experiences for intergroup experiences (Gros, 2007; Romero, Usart, Ott, Earp, & de Freitas, 2012; Hämäläinen, R., & Häkkinen, P., 2010).

Yet, the degree to which K-12 teachers intentionally plan for and orchestrate collaboration through game-based lessons is not well-documented, nor is the degree to which they are trained for this work. Instead, much of the literature focuses on the degree to which games are developed to incorporate collaboration, or the degree to which children collaborate through game-based lessons as orchestrated by researchers (who are often not their teachers). Much of basic teacher training is about child development, constructing lesson plans, and incorporating scaffolds for learning -- how much preparation do K-12 teachers have on how to use games in their classrooms for a productive learning experience? Research has shown that simply having students "play a game" that includes collaborative aspects will not lead to high-level collaboration (Hämäläinen, R., & Häkkinen, P., 2010).

Method

K-12 teachers in twelve online sections of a graduate-level educational technology course called "Using Technology to Build Learning Communities" gave their consent to participate in this study (n~50). The course includes readings, discussion, and activities around SMART goals for lesson planning, CSCL theory, and current collaborative technologies (such as games) for the K-12 classroom. The data collected from the participants for this study included two assignments that instructed them to prepare the game-based lesson: (1) a description of a performance task and (2) a lesson plan with a reflection. The graduate students completed these assignments as part of their regular coursework and submitted it to the researchers at the end of the term. The researchers then used a qualitative coding method (Chi, 1997) to analyze the participants' submissions for common themes and patterns related to collaboration and game-based learning.

Preliminary results

The results from the initial coding of the lesson plans show that a vast majority of the in-service teachers' plans included descriptions that indicated some kind of student-to-student collaboration would occur over the course of the game-based lesson(s) that were planned. Despite this mostly positive indicator, only 20% of the plans indicated that the majority of this collaboration would occur through, within, or around the game-based technology the teachers incorporated. Further, a majority of the technologies, game-based or other, that were selected by the in-service teachers focused primarily on memorization and recall of content facts. Very few of the lessons included any connection to engaging students in higher-order thinking while they used the technology or collaborated with their peers. Finally, only a few of the teachers' reflections mention the idea of collaboration playing a role in their thinking around how they might change or improve upon the initial design of their lesson(s).

Next steps

As more lesson plans are collected and analyzed in the next few terms, the patterns and themes around collaboration and game-based learning will become clearer. The initial course was designed based on a simple assumption, if we provided the in-service educators enrolled in our course with exposure to literature, examples, and facilitated discussion around the ideas of collaboration and learning communities, inquiry learning, and game-based instruction, they would take up the work of trying to plan for student-to-student collaboration as they worked to enact a technology game-based performance task in their settings. So far, the results indicate that this assumption was only partially correct. A vast majority of the in-service educators did explicitly include the ideas of student-to-student collaboration in their plan(s). However, almost all of the students failed to make any connection to leverage technology in ways that would support such work or that went beyond simple "drill and kill" repetition of content facts. These results highlight the reality that few of these educators made the connection between how learning communities and collaboration might be leveraged through technology.

These early results raise a number of questions as we continue to collect data. First, what type of experiences do inservice educators need to engage in so that they can build their capacity to leverage technology beyond the substitutive ways seen in this initial data set? Secondly, what scaffolds are necessary to support educators in selecting technologies that align with their stated learning goals while also providing opportunities for higher level thinking to occur? Further, what supports are necessary for these educators to think about and plan collaboration through or assisted by technology? Finally, how do we restructure the experiences of graduate-level courses to allow for the connections to be made between technologies and the collaborative tasks our educators are asking their students to participate in?

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Collaborative Scientific Modeling in the Classroom

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Abstract: Scientific modeling is a core component of learning in the modern science classroom. However, students do not always have the opportunities and supports to successfully engage with modeling. We have developed EcoSurvey, a digital modeling tool to support students as they explore the organisms and interactions found in the local ecosystem. We can use this tool to support equitable learning opportunities and develop a better understanding of students' real world modeling practices.

Introduction

Modeling is a core disciplinary practice in science and engineering, and an important skill to learn in the science classroom. The *Framework for K-12 Science Education* lists modeling as one of eight core science and engineering practices to develop across classrooms (National Research Council, 2012). Nevertheless, challenges to implementing modeling in the classroom have been documented by learning sciences researchers, including variations in the teachers' approaches to modeling (Windschitl, Thompson, & Braaten, 2008) and variations in how students engage with modeling practices (Schwarz et al., 2009, Bryce et al., 2016). These variations can lead to differences in students' opportunities to learn important modeling practices (McDonnell, 1995).

Our research focuses on how digital modeling tools in the classroom can influence equity in opportunities to learn. We have developed EcoSurvey, an online modeling tool students use to characterize organisms and the interrelationships found in their local ecosystems. With this tool, students photograph, map, and characterize local organisms, document how those organisms interact with each other and with shared environmental resources such as food, water, and shelter, and identify resources and species that are important to maintaining the health of the ecosystem. Students work together in their classrooms to create a shared ecosystem model that includes more complexity than would be feasible for one student to accomplish alone. We look at how usage logs from EcoSurvey reflect engagement with modeling practices for hundreds of students.

Theoretical framework

Modeling practices

Learning sciences researchers have spent a considerable amount of time analyzing the process students use to construct scientific models in the classroom (Schwarz et al., 2009, Bryce et al., 2016). Schwarz et al. (2009) identify a series of modeling practices that include identifying the anchoring phenomena, building an initial model, testing and evaluating the model, revising the model based on evaluations, and using the model to predict or explain phenomena. Similarly, Bryce et al. (2016) emphasize the importance of identifying the anchoring phenomena through observation, constructing the model, evaluating and revising the model, and using the model to solve a problem. This research suggests that supporting students as they engage in these practices can lead to positive learning outcomes (Schwarz et al., 2009). Our work examines how the usage logs reflect students' engagement with these practices.

Equity in modeling

Student learning outcomes can be attributed, in part, to differences in their opportunities to learn different topics (McDonnell, 1995). For instance, in a classroom setting, the opportunity for iteration can be driven by the structure of the class: students will not expand or refine their model if they are not given the opportunity to do so. Differences in student learning can also depend on curriculum as well as teacher and classroom level differences in implementation. Windschitl et al. (2008) conducted a series of studies examining how K-12 teachers integrated student modeling into their classrooms and found significant variance in teacher understanding and adoption. We leverage the flexibility of a digital modeling environment to scaffold student modeling and support students' engagement with modeling practices.

EcoSurvey

EcoSurvey is part of a larger curriculum development project for middle and high school biology classrooms. For the ecosystems unit of the curriculum, students use EcoSurvey to create a model of the local ecosystem's organisms and interactions. Students use this model as evidence for choosing a tree to plant at a local site, such as the school grounds. Our team is analyzing the use logs from over 800 students in a large urban school district in the Midwestern United States to understand how students engage with modeling in the classroom.

Within EcoSurvey, students join a class "survey", take photos and field notes on organisms they find on their school grounds, and create a "card" for each organism. Students add details to each card about the organism including its role in the ecosystem and relationships with other organisms. EcoSurvey is designed to support peer-review, allowing students to provide feedback and make edits to cards easily. These models are visualized in a graph view, allowing for further review and use as evidence as the proper tree to plant.

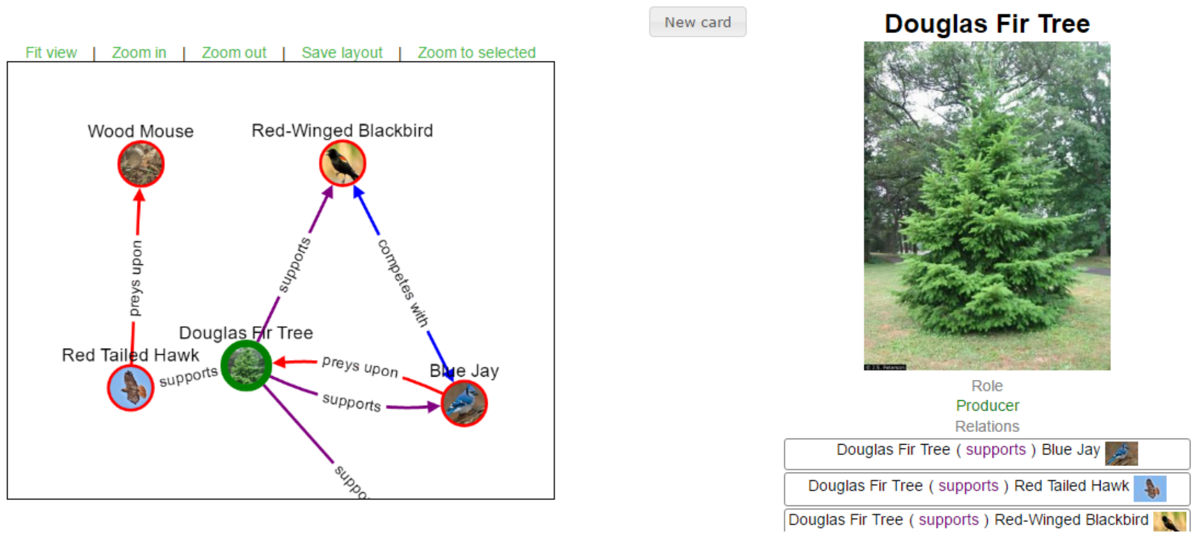

Figure 1. The EcoSurvey Graph View, With Accompanying Detail Pane.

Analysis of the first version of EcoSurvey revealed a large amount of variance in final student models and in students' engagement with modeling practices at the classroom and teacher levels, and these differences were predictive of a student's teacher. We designed the current version to help eliminate these differences and provide more opportunity for students to engage with modeling practices. One of the largest gaps between teachers was the level of engagement with the graph view functionality. We decided to incorporate this graph view throughout the students' workflow. This view promotes students to look at the model as a whole, promoting stronger review and the development of connections between students' pieces of their shared model. This promotes equity in the learning process, supporting students' creation of a professional model and providing an opportunity for students to wrestle with ecosystem elements that they may not yet understand.

Overall, EcoSurvey is a promising opportunity for understanding collaborative scientific modeling in the classroom. With this tool, students can engage in the full set of modeling practices in an iterative fashion, using the status of the model to determine what work needs to be done next. EcoSurvey also provides students with the chance to participate in authentic science, building a model to use as evidence for which tree to plant. In turn, we can study student usage to gain a better understanding of the flow of activity found during modeling activities in the classroom.

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Go GRASP: A Mobile Application to Facilitate Orchestration in Active Learning Classrooms

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Abstract: Dillenbourg-lanterns are *classroom augmentation* tools that help instructors orchestrate group-sessions. Instructors get ambient feedback on groups: ahead/behind class (Lantern color), need help (flashing Lantern), waiting longest (flash rate). Groups can use ambient feedback to determine which group is ahead and could help. We describe the design-based research development of an application called GRASP (Group Response Ambient Student Participation) that converts student's mobile devices into Lanterns. Data collected in GRASP could deepen our understanding of orchestration.

Introduction

Student-centered active learning is an instructional model that was shown to be more effective than teacher-centered didactic teaching (Freeman et al., 2014; Meltzer & Thornton, 2012). However, active learning presents challenges that can prohibit widespread adoption. In teacher-centered classrooms, instructors control what will happen in 10, 20 or 30 minutes. In student-centered classrooms, instructors must respond to students' needs in a manner that is difficult, if not impossible, to plan. Different groups can have simultaneous needs. This places an orchestration load, on the instructor who must simultaneously respond to different groups (Dillenbourg, 2013; Roschelle, Dimitriadis, & Hoppe, 2013; Sharples, 2013). To reduce orchestration loads on instructors, Dillenbourg created the Lantern (Dillenbourg & Jermann, 2010; Dillenbourg et al., 2011). Lanterns help instructors manage group problem sessions by shining a specific color for each assigned question. A group shows it finished a question by changing lantern's color (each question being assigned a color). To call the instructor, students make the lantern flash, the flash rate increasing as wait time increases. Instructors thus get ambient feedback on which groups are: 1- ahead or lagging behind, 2- need help, 3- have been waiting longest. Groups can use ambient feedback to determine which other group is ahead and could help them. Furthermore, students no longer devote time to calling the instructor, so groups will often spontaneously solve their issue before the instructor arrives. We describe a designed-based research development of an application called GRASP that uses student's mobile devices as Lanterns. A clickable prototype (https://marvelapp.com/fehiid) and preliminary functional version are available (www.gograsp.org).

Description of GRASP: Instructor view

GRASP differs in interesting ways from the original lantern. Foremost, Lanterns are assigned to groups. Each student with a mobile device has a GRASP Lantern. Only instructors need to create a profile (requires only name, institution and email). Instructors create a new session or retrieve data previously collected in GRASP (Figure 1a). New sessions require specifying the title, number of questions and sub-questions (Figure 1b). When a session is initiated, the screen of students' devices lights up, as lanterns do, and follow similar behavior (color changes with new questions, flashes to call the instructor).

Figure 1a. Create session.

Figure 1b. New session.

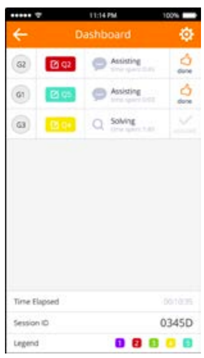

Figure 1c. Ongoing session.

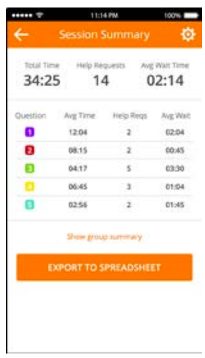

Figure 1d. Summary data.

In GRASP instructor have a dashboard that shows what each group is doing, prioritizes help requests for earlier questions and shows wait times (Figure 1c). After an instructor ends a session, a session summary providing all relevant information is displayed and can be exported (in csv format) to the instructor's email (Figure 1d).

Description of GRASP: Student view

Our application was designed to be as simple and light as possible with minimal configuration. Instructors need not upload class lists. Hence, students can login using their name or an alias (Figure 2a). All that is required for a student to login is a name/alias and the session ID associated to the session their instructor created (see Figure 1c, session ID = 0345D). Students then join a group that has group members they recognize, or create a new group (Figure 2b). Once in a group, the screen of the mobile device stays on and shines a uniform color associated to the first question (Figure 2c). Should a student in the group decide to ask a question or pass to the next question, other members of the group receive a notice of a motion to change questions or request help. Another group member must approve the motion. This prevents individual students from moving forward without their peers or from requesting help from the instructor when someone else within the group can assist.

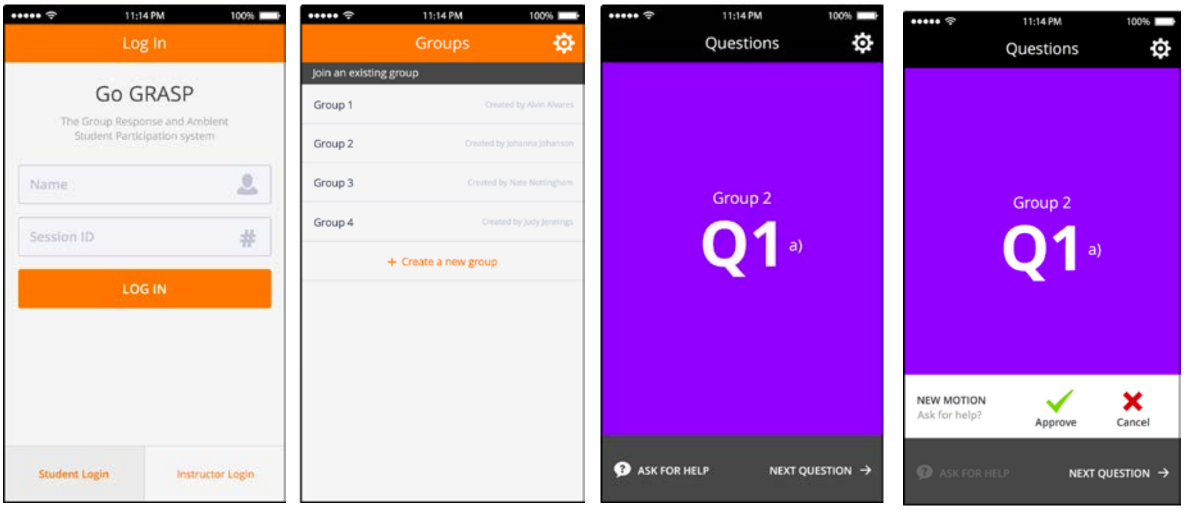

Figure 2a. Login screen. Figure 2b. Group selection. Figure 2c. Question. Figure 2d. Approval of motion.

Given that all data collected in GRASP can be stored and analyzed at a later date, our application provides more granular data. The designs presented here are first iterations of our design-based research project. We built the tool around orchestration load theory and are proceeding to implement its use in active and non-active learning classrooms. This should provide data that will reshape the design of the tool and potentially inform current theoretical frameworks on orchestration theory.

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Cued Gestures: Their Role in Collaborative Discourse on Seasons

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Abstract: Many studies of body-based digital learning environments focus on use with large groups or individuals. This study explores the use of a gesture based computer simulation with a small group. Using a case study approach, we found that middle school students used gestures cued by the simulation to engage in collaborative discourse about progressively more causal explanations of seasons. Additionally, we found that students appropriated some of the gestures as resources for individual explanations of seasons.

Keywords: embodied learning, gestures, simulations, explanation, science education

Introduction

There is a growing area of research on digital environments that promote embodied learning (Lindgren & Johnson-Glenberg, 2013). Much of this research has examined embodied learning environments with large groups (e.g., Enyedy, Danish, Delacruz, & Kumar, 2012) and individuals (e.g., Lindgren, Tscholl, Wang, & Johnson, 2016). The present study adds to the literature on embodied learning with a focus on a small group of students (i.e., three or fewer).

Recent reform documents in U.S. science education advocate modeling and constructing explanations as practices to support learning of disciplinary core ideas such as causes of the seasons (NGSS Lead States, 2013). Interventions to support students with these goals are needed because research shows that students persistently have difficulties developing causal explanations of seasonal change (e.g., Plummer & Maynard, 2014). Crowder (1996) found that students spontaneously gesture to support self-explanation and explanation to others in the context of modeling causes of seasons. We shift focus from spontaneous gestures to studying intentional cueing of specific gestures to support students with developing explanations of seasons. Lindgren (2015) has suggested that this process of cueing gestures may support conceptual development for students. Therefore our aim was to investigate how a simulation learning environment that cues gestures is used by a small group of students for the purpose of developing causal mechanistic explanations of seasons.

This study involved examining individual students' conceptions as well as the social environment that mediates the formation and modification of their conceptions. The specific research questions addressed in this study are: (1) What is the role of cued gestures in the discourse of a small group? (2) How do individual students use cued gestures in explanations of seasons?

Methods

We used a case study approach (Stake, 1995), which was appropriate given the need to understand the particular interactions of one group of students. Over the course of three weeks, the first author observed three periods of an eighth grade classroom in a public middle school in the Midwestern United States. The instructor, who was an experienced teacher, enacted an astronomy curriculum unit that emphasized modeling. During this unit, students' primary task was to construct models of various phenomena such as phases of the moon and how seasons change. The unit had already included a computer simulation of seasons, which was replaced by a seasons simulation with gesture interaction capabilities for the purposes of this study. The simulation included multiple views of the earth and sun, such as a view of the earth's orbit around the sun and a ground view of light rays striking the earth. Students were instructed to set up specific views in the simulation and to use specific gestures (i.e., cued gestures) to interact with the simulation. For example, the cued gestures in the ground view asked students to use their hands to represent light rays. When students changed the angle of their hands, they saw a change in the angle of light rays on screen, and the earth simultaneously moved to the location in its orbit corresponding to the angle of the sun's rays. Two additional cued gestures enabled students to also embody the concentration of light rays and the angle of the ground relative to the light rays.

All students were invited to participate in this study, but only those who had parental permission were included. From the students who volunteered, the teacher assembled two groups in each class period to be video recorded. The video from one group of three students is the primary data source for research question one. Research question two was addressed using data from the individual group members' pre and post assessments that were included in the unit as well as individual interviews conducted by the first author at the end of the unit.

Findings

Collaborative discourse around cued gestures in a simulation

The group that was analyzed included three students: Alice, Cynthia, and Michael (pseudonyms). Shortly after they first started using the simulation, they discussed what their hands were representing on the screen. During their conversation, Alice and Cynthia worked together to make sense of what the rays on the screen represented. Michael added the key idea that the rays were rays from the sun. From that point, Alice and Cynthia observed differences in the angle of their hands and the rays during different times of the year, noticing that they were more direct during summer months and less direct during winter months. This joint attention to the role of light rays added explanatory power to their causal model of seasonal change.

During the next class period, the group continued working with the simulation with a new cued gesture that involved representing the average concentration of light rays on a patch of ground at different times of the year. Alice and Cynthia made an important connection when they linked a difference in light ray concentration to a difference in temperature, and the also associated a lower concentration of rays with the winter months in the northern hemisphere. It is noteworthy that Michael was not involved in this conversation and was more distant from the group as he moved to a flat surface so he could write notes. From this episode we saw that the cued gesture was involved in the discussion of the causal relationship between light ray concentration and temperatures experienced at a location on earth. While this episode illustrated that a cued gesture could prompt joint meaning making, it also raised questions about whether the group arrangement would be more effective with two students rather than three students.

Appropriation of cued gestures in individual explanations

At the conclusion of the unit, students were interviewed individually and asked to explain why we experience seasons. During these interviews all three students used some of the gestures that had previously been cued by the simulation as part of their explanations. This finding is expanded upon and illustrated on the accompanying poster.

Implications

This study showed that cueing gestures in a simulation learning environment can promote collaborative discourse about theoretical entities such as light rays, at least with pairs of students. Future research should explore collaborative discourse on other topics in order to identify broader themes that characterize effective uses of embodied learning environments. This study also showed that students can draw upon the cued gestures as resources to reason about their models of seasonal change.

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Habits of Civic Collaboration in a Digital Carnival: Fostering Other-Oriented Collaboration in a High School Game Making Workshop

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Abstract: In this paper we identify one unique aspect of civic collaboration, its other-oriented focus – projects intended for the use of others. In an exploratory study, high school student teams designed digitally augmented versions of carnival games using Scratch and MaKey-MaKey. Relying on Dewey's vision of citizenship education as participation in democratic learning environments, our analyses highlight how iterative game design has the capacity to facilitate situated and collaborative perspective taking concerning players' perceptions and behaviors.

Introduction

New modes of interaction and communication facilitated by digital media have reshaped the civic sphere, introducing more collaborative forms of civic participation (Kahne, Hodgin, & Eidman-Aadahl, 2016). These shifts introduce novel challenges for educators, who must prepare students for more flexible and open-ended forms of civic action. One response to these challenges has been re-emergence of Dewey's (2001) century old vision of civic education as the cultivation of democratic habits – meaningfully ingrained democratic modes of behavior (e.g., collaboration, deliberation) developed by immersing students in contexts in which they serve academic ends. Though not dedicated to civic education, computer supported collaborative learning (CSCL) has been a central context for studying the cultivation of open-ended collaborative endeavors characterized by active and critical participation (Scardamalia & Bereiter, 2014). We complement this rich body of research by focusing on an aspect of civic collaboration which merits more attention, its *other-oriented* nature – collaborative endeavors whose end-products (material or abstract) are intended for the use of others.

One of the main aims of civic education in a liberal democracy is to cultivate students' propensity to pursue public projects guided by the understanding and appreciation of the diverse perceptions of various social groups beyond their own (Kahne et al., 2016). A central aspect of this endeavor is developing students' capacity for perspective taking – viewing issues from diverging perspectives. Research has shown that the process of iterative game design can elicit intrinsically motivated perspective taking, stemming from designers' attempt to assess and predict the conduct of future players across a host of possible choice sets (Flanagan & Nissenbaum, 2014). Moreover, the iterative game design cycle – generating game ideas, playtesting, and analyzing the results (Zimmerman, 2003) – demands a complex and situated process of perspective taking: predicting players' behaviors when designing the game, analyzing players' conduct during playtesting, and manipulating game mechanics in an attempt to reshape players' experiences.

Context and methods

We designed and conducted a *digital carnival* workshop with 16 high school freshmen (6 girls, 10 boys, ages 14-15). Relying on the MaKey MaKey's ability to interact with the Scratch interface and transform conductive materials into touch-sensitive buttons, teams created digital versions of classical carnival games (see Figure 1). Situated in a metropolitan city in a US northeastern state, the workshop spanned over 17 hours, which included eight two-hour meetings, and a final *digital carnival* where students presented their games in their school. In order to examine the other-oriented collaboration facilitated in game making we triangulated the following data sources: (i) observational field notes and video recordings documenting group interactions; (ii) students' own perceptions of their work collected through weekly reflections exercises, feedback forms, and semi-structured debriefing focus groups; (iii) a descriptive review of participants' games relying on group' Scratch code, video recordings of playtesting sessions, and a professional game designer's feedback on the games.

Case study of other-oriented collaboration

Using these data sources, we developed a case study of one group's work on their final project – *Dictator Donkey* (Figure 1) – through three cycles of playtesting. As their design constraint, the *Dictator Donkey* group (3 boys and 1 girl) had to create a digital iteration of *Pin the Donkey.* Their initial design (Figure 1) consisted of a real-life blindfolded player holding a conductive stick who had to cross a real-world obstacle course and reach a donkey at its end. If the player accidently touches one of the obstacles (aluminum covered boxes), a circuit would be closed and the player would lose, resulting in visual and audio effects designed in Scratch onscreen.

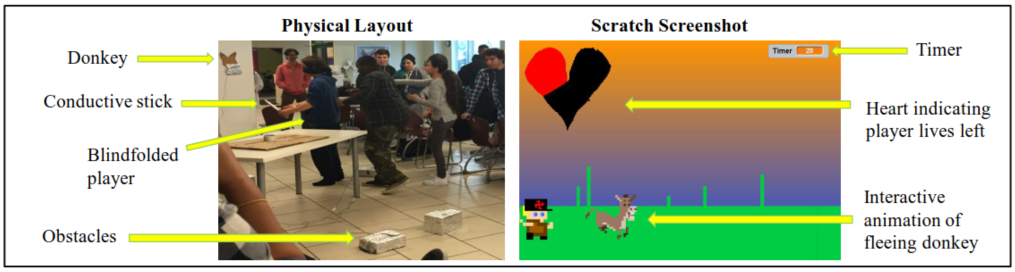

Figure 1. *Dictator Donkey* – Final Project Setup.

During the first round of internal testing players were wary of walking across the obstacle course blindfolded. As a result, the group decided to experiment with the idea of adding a guide charged with leading the players. However, in the next playtesting session, which included feedback from a professional game designer, the game had become too easy. The professional game designer encouraged students to think of a way to counteract this by tinkering with the game mechanics rather than merely adding obstacles. The group decided to turn this into a competitive game by charging game spectators with the role of confusing players by yelling conflicting directions. This tinkering of the game mechanics proved to be a great success in the *Digital Carnival* and the game drew many players and enthusiastic participation by spectators.

Discussion

As students set out to design their game, they needed to consider the game from the perspective of future players. While this may seem fairly obvious, it is actually one of the more challenging aspects for beginning designers, who tend to focus solely on their own perspective. Initially, the group failed to consider the perspective of others, and were confronted with their lack of perspective taking in the playtesting stage. During playtesting sessions, the team collaboratively offered ideas concerning how to change the game and engaged in a trial and error process of these manipulations in later playtesting sessions. In this respect, this process is particularly attuned to the challenges of other-oriented collaboration in the evolving civic sphere: planning projects that are sensitive to the perceptions of others, attempting to make these plans a reality, and learning how to modify these plans in light of their practical results. Hence, game making affords a unique perspective taking experience in comparison to learning in class about other perspectives, viewing them brought to life through art or reporting, or experiencing them through playing a game. We suggest that this model of iterative design can be a useful framework for cultivating other-oriented civic collaboration in a variety of educational contexts directed towards the need of others (see Figure 2).

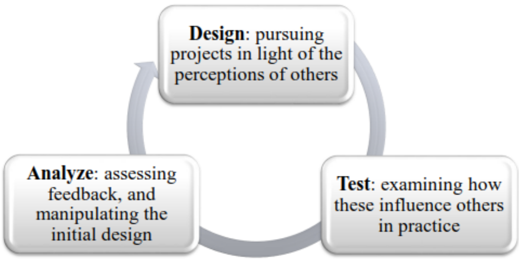

Figure 2. The Iterative Design Cycle Applied to the Cultivation of Other-oriented Civic Collaboration.

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Co-Regulation Competences: Can They Be Measured?

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Abstract: Co-construction of knowledge strongly builds on learners' ability of co-regulation, which may or may not be related to skills of self-regulation. In our study, we ask the question whether co-regulation learning strategies are detectable with questionnaires and what relationship does self-regulated learning strategies have with co-regulated learning strategies. Our results showed that the Co-Regulation Competencies Questionnaire (CRCQ) detected co-regulation learning strategies and the extent to which self-regulated learning strategies are related to co-regulated strategies.

Introduction

In CSCL, regulation research has recently changed focus from an individual perspective of self-regulated learning (SRL) to more emphasis on shared regulation behaviors (Panadero et al., 2015). Hadwin, Järvelä and Miller (2011) stated, "co-regulation is the temporary coordination of self-regulation amongst self and others" (p. 68).

By the very nature of co-regulation, the learners first need to *share* to engage in co-regulated behaviors (Järvelä & Järvenoja, 2011), but can the intentions of sharing one's learning strategies be measured? There are several self-evaluated learning strategies assessments, like Pintrich's (1991) Motivated Strategies for Learning Questionnaire (MSLQ), but there have been few attempts to measure co-regulation with questionnaires. One of the few studies was DiDonato (2013) who measured co-regulation by replacing the "I" (self-efficacy scale) with "We" (collective efficacy). Schoor et al. (2015) argued a thorough understanding of how to measure self-regulation is important, but co-regulation is a separate phenomenon and requires its own methods.

In our pilot study, the *Co-Regulation Competencies Questionnaire* (CRCQ) was developed and tested. Researchers have argued that students who can self-regulate themselves does not guarantee that they can also co-regulate in a group (Chan, 2001). A better understanding of co-regulation can assist in fostering learners' self-regulation learning strategies. For example, Hadwin's et al. (2005) examined teachers' co-regulatory activities and found after introducing co-regulatory activities, the students gradually increased their use of self-regulatory strategies.

The development of CRCQ aims to complement other qualitative methods in CSCL. The following questions were asked: (1) Can co-regulation competencies (e.g. learning strategies) be reliably measured by using a questionnaire?, (2a) What relationships can be found between the CRCQ's scales?, (2b) What relationships can be found between the MSLQ's scales?, and (3) What relationships can we find between self-regulated and co-regulated learning strategies?

Method

Participants (N=45) between 19 and 65 years old (M=36.93, SD=11.22) completed our CRCQ and MSLQ. The CRCQ contains 84 items and measures similar constructs as the MSLQ, but linked to the learners' co-regulatory learning strategies but asking learners to assess their *sharedness* of their strategies: cognitive (e.g. rehearsal, organization, elaboration, critical thinking, collective efficacy), metacognitive (e.g. planning, monitoring, goal setting), and motivation (e.g. intrinsic/extrinsic motivation, task value, control beliefs). The items (i.e. statements) were given and participants rated them with either no sharing, sharing a little with a group member, sharing a lot with a group member, sharing with a group member and a little with the group, sharing with a group member/whole group, and sharing a lot with whole group and a little with a group member, or not relevant.

Results

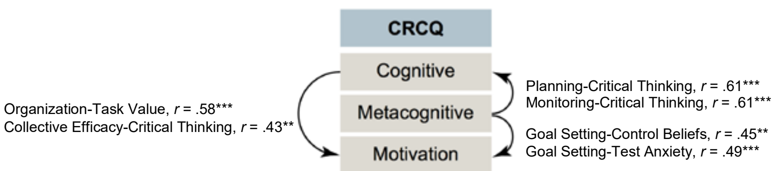

Figure 1. Research Question 2a ($p < .01$**, $p < .001$***).

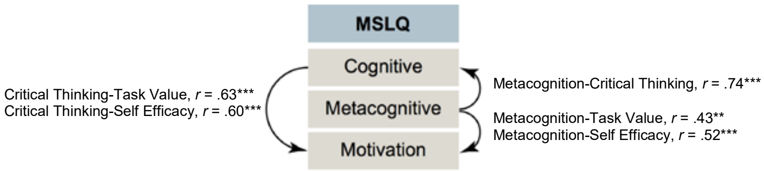

Figure 2. Research Question 2b ($p < .01$**, $p < .001$***).

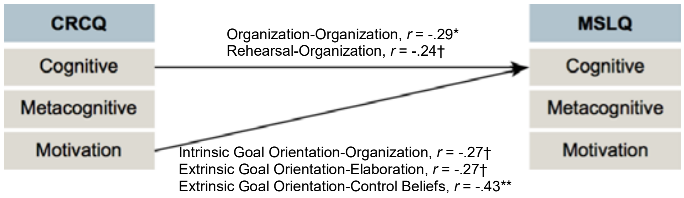

Figure 3. Research Question 3 ($p < .10$†, $p < .05$*, $p < .01$**).

(1) High Cronbach Alpha scores were found with 14 out of 17 CRCQ scales with an $\alpha > .60$. Intrinsic goal orientation ($\alpha = .55$), control beliefs ($\alpha = .47$), test anxiety ($\alpha = .52$), and effort regulation ($\alpha = .55$) were the only low Cronbach Alpha scores found.

Discussion and future work

(1) Despite a few lower Alpha scores, we can be confident in the reliability of the CRCQ. Regarding research questions (2a), in several cases, the learning strategies in the CRCQ positively related to each other similar to positive relationships found between the learning strategies in the MSLQ (2b). The negative correlations between self- and co-regulation learning strategies confirm the assumption and answers research question (3). There is clear evidence that good self-regulated strategies do not translate to good co-regulatory strategies (Chan, 2001).

Further in-depth investigation with observational data, which would contribute to the cross-validation of our CRCQ, is planned to understand the initial CRCQ's results and ultimately to fully investigate the dynamic phenomena of co-regulation in a CSCL environment. We will explore co-regulation competencies using videotaped sessions and individual/group unit of analysis coding scheme based on Winne and Hadwin's (1998) COPES' model.

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SynergyNet Into Schools: Facilitating Remote Inter-Group Collaborative Learning Using Multi-Touch Tables

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Abstract: The availability of more mobile large factor touch-screen interfaces has allowed for research into collaborative learning that has previously taken place in single laboratory environments to be carried out at multiple schools in the real world simultaneously. This research focuses on a study which used the framework to investigate collaboration between groups of students at two geographically separate sites. The groups from the separate sites worked together to complete a task using video-conferencing and a novel flick gesture provided by the SynergyNet framework to transfer materials to each other. This paper details initial findings and the steps being taken to robustly analyze the data collected.

Introduction

Despite the proliferation of tablet computers in schools, there is still a great deal of potential for multi-touch tables which support optimum learner participation in face-to-face collaborative activity (Stahl, Koschmann and Suthers, 2014; Dillenbourg and Evans, 2011). As such, large touch screen interfaces offer opportunities for collaboration between learners either when the interface is shared or when two or more co-located interfaces are networked together allowing for the transfer of materials. This study builds on prior research into the observed behaviors of learners (10-11 years) collaborating in small groups in History and Mathematics problem solving activities. An interdisciplinary EPSRC/ESRC (UK) funded research project, SynergyNet, identified important technical and pedagogical challenges in the development of multi-touch technology. The project successfully explored issues of classroom talk and emergent leadership (Higgins et al. 2012), adaptive expertise (Mercier and Higgins, 2014) and teacher dialogue (Joyce-Gibbons, 2016).

Study design

The original SynergyNet study was limited to use in a laboratory built to emulate a classroom rather than in regular school environments. This was necessitated by the constraints of the technology. Recent developments of more portable and robust multi-touch tables mean that recent research using the SynergyNet framework can take place in real-world school settings. However, rather than simply replicate the previous configuration of co-located groups working together, the researchers sought to use the capabilities of the SynergyNet tool to their fullest potential by developing shared learning practices between small groups of learners (9-10 years old) in two schools, working simultaneously on a project. Despite their distance apart (approximately 300 miles), Durham City in England and Caerphilly in Wales have a shared industrial and coal mining heritage. Both have recently undergone privations in dramatic de-industrialization. The impact this has had on young learners has been one of disassociation. They struggle to equate their own reality with the initial raison d'être of the villages in which they live. To help support the development of a shared sense of learner belonging and historical perspective, groups were asked to collaborate on a History mystery classroom task (Leat and Higgins, 2002). This activity centers around a complex problem, multiple possible answers were contained in 20 clues shared between the two groups, one in each location. The task was to reconstruct the events leading up to an accident in a mine involving a 10 year old boy and to apportion blame for his misfortune.

These learners were linked by Skype, to support communication, and by the tables, through which they could share data via a feature called 'Network Flick'. This feature allows learners to transfer content from one table to another using a flicking gesture. 'Flicking' shared clues between locations gave a sense of spontaneity and fluidity which typical file-sharing methods do not allow (McNaughton *et al.* in press). It also scaffolded groups in negotiating salience for the clues on their table. The clues they perceived as important were flicked and those deemed less salient were not.

Preliminary findings

Initial data suggests that the remote nature of the groups did lead to meaningful collaboration but in a very different form to that observed in the original studies which focused on intra-group rather than inter-group collaboration. In the early study, groups organized their thoughts using representations on the table to negotiate shared understanding. In the recent study learners immediately share key information with the partner group, leaving only information they have decided is unimportant on their table. Learners easily created a joint attention space, particularly around information sent by the remote group. However, this led them to an over-focus on individual pieces of text rather than on developing a general understanding.

Groups in both locations easily established joint working practices aimed at sharing important information with each other and attracting the attention of the other group. If one participant waved at the partner group, it was generally ignored as erroneous. However, if all members of the group waved together the viewing group knew to initiate dialogue. There were conscious exchanges involving procedural and solution focused discussion. There were also clear sub-conscious communication processes involving mirrored body language and modulation of intonation to match unfamiliar accents.

Teacher behavior was focused in two areas. First helping groups establish better physical collaborative practices to more effectively use the tables. This entailed changing their position in relation to the camera used for Skype or suggesting improvements to their technique when performing multi-touch gestures on the table interfaces. Second, teachers helped learners shift their focus from the specific (a single clue sent by learners in the other group) to the general (understanding the place of this clue in the wider context of developing a plausible solution to the task).

Delayed interviews with participants, conducted seven months later, indicated that the students remembered some aspects of the activity very vividly, particularly interacting with the partner group through flicking gestures and through skype. Typical comments include: i) "It was like being in a house full of strangers"; ii) "We communicated like we were really there."

Further analysis

Currently, teacher dialogue is being analyzed using an adapted version of the Engle and Conant (2002) framework. This is being used to explore the extent to which the participating leaners were able to support and scaffold both successful collaboration and successful task completion. Learner behavior is being explored using the metaphors of participatory learning, knowledge acquisition and knowledge construction (Lipponen et al. 2004) as a framework for interpreting individual's experiences of collaborative working. This work is due for completion in April 2017.

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Affordances and Constraints of Immersive Virtual Environments for Identity Change

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Abstract: This paper examines the affordances and constraints of immersive virtual environments for facilitating learning as identity change. The Projective Reflection framework (Foster, 2014) served as a theoretical framework for this study. Projective Reflection is the process by which a person, who is engaging in digital gameplay or virtual environment, constructs and/or enacts an identity in a game/virtual environment that has the potential to modify the person's possible/future self and lead to a new sense of identity in a domain (Shah, Foster & Barany, In Press). We investigated the design of three exemplary science games; namely, EcoMUVE, Land Science, and River City in order to examine their affordances and constraints for facilitating knowledge construction, interest and valuing, self-organization and self-control, as well as self-perception and self-definition in science. The paper reports preliminary findings.

Theoretical framework

Projective Reflection (PR) is a framework that facilitates identity change in an individual over time (Foster, 2014). The framework comprehensively informs the process of identity exploration as an antecedent to identity change, and as such, allows for the support and tracking of learning as change in students' knowledge (Kereluik, Mishra, Fahnoe & Terry, 2013), interest and valuing (Foster, 2008), self-organization and self-control (Hadwin & Oshige, 2011), and self-perception and self-definitions (Kaplan et al., 2014) for a targeted academic domain.

Methodology

This investigation is part of a larger 5-year NSF project that aims to develop and test a process of supporting learning as intentional identity exploration and change for students using immersive learning environments to learn science, and provide implications for designing and teaching in technological environments for learning as identity change (Foster, 2014). For this study, we analyzed the design features of EcoMUVE (Metcalf et al., 2011), Land Science (Bagley & Shafer, 2015), and River City (Ketelhut, 2007)- exemplary science games- along the four identity change constructs as defined by the Projective Reflection framework- knowledge, interest and valuing, regulated actions, and self-perception and self-definition. We used the playing research method (Foster, 2012) to analyze the games and gain knowledge about the affordances and constraints of the design through direct game playing experience and through vicarious means (e.g. research papers, website).

Preliminary findings

Knowledge

EcoMUVE, Land Science, and River City were designed to facilitate scientific content knowledge, which included knowledge of Urban Science and Scientific Modeling, Biology and Epidemiology, and Environmental Science respectively. All the games included features for facilitating learners' meta knowledge. This included skills such as analyzing, critical thinking, problem solving, hypothesizing, evaluating the solutions, communication and collaboration. For example, in River City players worked in small groups to investigate the causes of three types of diseases spread across the town and suggest possible solutions. The three environments provided limited opportunities for enhancing humanistic knowledge such as ethical/emotional awareness and life/job skills. For instance, although Land Science provided some opportunities to empathize with different stakeholders within the game, it did not explicitly prompt players to relate their in-game experience with the real-world context. Lastly, all the projects provided players with opportunities to use a variety of tools to navigate the game effectively and achieve the desired learning goals. For instance, the tools players used in EcoMUVE included field guide, the population tracker, the camera, the data view, and the calendar.

Interest and valuing

The current designs of the games were intended to trigger players' interest in the domain. However, the games were found to provide limited opportunities for enhancing learners' personal interest and valuing of science outside the context of the games. For instance, in EcoMUVE players undertook the role of an environmental scientist and explored the various causal relationships in the virtual ecosystems. However, the game did not prompt them to set their personal goals or elicit reflections on how relevant their experience as a Water Chemist or any other job-role was to their personal interest and choices in learning about science and scientists.

Self-organization and self-control

The three environments were designed to engage learners in co-regulated actions such as problem solving jointly and establishing common goals. For instance, in Land Science group work was facilitated by an assigned mentor, who provided instructions for upcoming tasks and guided players through the play activities. Players could engage in socially-regulated actions such as seeking guidance, co-constructing knowledge, and joint problem-solving in all the games. For example, in River City students were required to collaborate with their team members to make complex choices and understand different forms of interactions in the virtual world in order to solve the problem of disease-spread. Lastly, all the environments allowed players to engage in self-regulated actions such as paying attention to feedback, taking cues from social guidance, demonstrating competence with tasks, self-efficacy, and self-awareness. For example, EcoMUVE offered opportunities for enhancing players' competency with the task and self-efficacy by engaging them in scientific data collection, analysis, and interpretation. Players used the tools such as the field guide, the population tracker, the camera, the data view, and the calendar to evaluate and monitor their own progress within the game.

Self-perception and self-definition

EcoMUVE, Land Science, and River City offered a safe environment for learners to explore a definite number of identities. However, the games had limited opportunities for scaffolding the explorations and adapting them to each students' interest and valuing, regulated actions, and knowledge construction. As a result, learners were seldom prompted to intentionally reflect on their in-game experiences and how they informed how the learners saw themselves, what they wanted to be, and what they expected to be in relation to careers in related scientific fields.

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The Effect of the Screen Size of Multi-Touch Tables on Collaborative Problem Solving Interactions

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Abstract: This study explored whether interactions differed between dyads working on multi-touch screens of different sizes. Dyads solved a scientific mystery on 11”, 27” and 80” multi-touch tabletops. Video analysis indicated differences in the quality of interactions, types of reasoning, the time needed to propose an evidence-based solution, and the actions associated with the screen between pairs in each condition. Results indicated that the 27” screen size was most suitable for this type of task.

Introduction

Research has shown that multi-touch tables can facilitate face-to-face collaborative problem solving interactions (e.g. Harris et al., 2009; Mercier et al., in press), support the creation of a joint problem space (Mercier & Higgins, 2014) and increase joint attention (Higgins et al., 2012). However, we do not know whether the screen size influences these interactions. This study explores the effect of the screen size of multi-touch tables on the collaborative problem solving interactions of pairs of university students who solved a scientific mystery on 11”, 27”, and 80” multi-touch horizontal screens. The study examines the differences in the quality of interactions, types of reasoning, the time needed to propose an evidence-based solution, and the actions associated with the screen of the tabletop between dyads in the three conditions.

A study by Ryall and colleagues (2004) examined the impact of screen sizes on the working strategies and the speed that groups assembled target poems using digital words. Results indicated that the size of the screen did not influence the distribution of work and had no significant effect on the speed with which groups constructed poems. However, studies have not investigated the impact of different screen sizes on collaborative learning or problem solving, where joint activity is central to the successful outcomes of group members.

The size of a multi-touch screen is a feature that can influence cost and storage, hindering widespread uptake of this technology. Therefore, understanding how screen size impacts collaborative problem solving interactions provides insight for those making decisions about whether to pursue the design and use of multi-touch devices for collaborative learning.

Methods

A between-subjects qualitative design was used for this study, with pairs of university students participating in one of three conditions (11, 27 or 80-inch screens). Eighteen undergraduate students participated (9 same-gender dyads); 4 were male and 14 were females. A within-subjects design was not used due to a concern that students would become frustrated moving from larger to smaller screens or that the habits developed while solving the first or second mystery would carry through and influence their interactions and reasoning.

Data collection

Data from one dyad was collected at a time. Dyads were randomly assigned to one of the conditions. After trying a short task with the multi-touch screen, dyads were left alone for 30 minutes to work on a scientific mystery that required them to find out what caused an outbreak of a fatal disease using a map and a set of clues. The task was designed with range of possible reasons for the cause of the outbreak, but only one correct answer. Two video cameras were used: one camera faced the dyad, while the second recorded the screen. Videos were transcribed.

Data analysis

Analysis was performed to assess the quality of interactions and types of reasoning. The interactions coding scheme was adapted from Higgins et al. (2012) to understand how the participants were building on each other’s ideas. Each turn was coded as independent, quasi-interactive, elaborative-interactive, negotiating-interactive, or other. The hierarchical Structure of the Observed Learning Outcome (SOLO) taxonomy (Biggs, 1995) was used to identify levels of reasoning. Each reasoning turn in each transcript was coded as pre-structural, uni-structural, multi-structural, relational, or extended abstract. To examine the differences in the time taken to propose an evidence-based solution to the mystery, the time taken by each dyad to reach the first turn that included a solution that is supported by clues available was recorded.

To examine whether there were differences in the actions on each screen, videos of the screens were simultaneously coded with the transcript. An emergent coding scheme that identified the actions that the dyads performed on the screens was used. It included a) moving or changing size of clues, b) grouping clues in a certain spot on the screen, c) laying clues over the map, d) moving or changing size of map, and e) referring to a certain clue or representation by pointing to the screen. The total time spent by every dyad on each action was calculated.

Results

To understand if there were differences in the interactions, the interaction codes were compared. There was a higher percentage of independent talk in the 11" condition (51%) than in the 27" (40%) or 80" (41%) conditions. There was a higher percentage of quasi-interactive talk in the 80" condition (42%) than in the 27" (36%) or 11" (35%) conditions. There was a higher percentage of elaboration and negotiation talk in the 27" condition (17%) than in the 80" (13%) or 11" (9%) conditions.

To understand if there were differences in how dyads reasoned across conditions, the SOLO codes were examined. Relational and extended abstract reasoning were similar across conditions. There was a higher percentage of pre-structural reasoning in the 11" condition (68%) than in the 27" (48%) or 80" (48%) conditions. There was a higher percentage of multi-structural reasoning in the 27" condition (36%) than in the 11" (16%) or 80" (28%) conditions. Dyads in the 27" condition proposed an evidence-based solution first (M = 6.91 minutes), followed by the 80" (M=8.82 minutes) and finally the 11" condition (M=9.96 minutes).

To examine differences in how dyads interacted with the different sized screen, their actions were compared across conditions. Dyads in the 11" condition spent more time moving or changing the size of the clues and laying cards on map (M=11.91 minutes) than dyads in the 27" (M=6.83 minutes) and 80" (M=8.35 minutes) conditions. Dyads in the 80" condition spent more time referring to a certain clue or representation by pointing at the tabletop (M=4.18 minutes) than dyads in the 11" (M=2.48 minutes) and 27" (M=2.53 minutes) conditions.

Conclusions

The results indicate that dyads in the 27" condition engaged in more elaboration of each other's ideas and in negotiating solutions to the mystery. Although all dyads proposed solutions to the mystery, dyads in the 27" and 80" conditions were engaged in higher levels of reasoning than dyads in the 11" condition who tended to read clues more than commenting on their value or connecting their content. Given that the mystery was a complex problem that included many clues, creating external representations was necessary to manage these clues and ensure common understanding of the mystery. It appears that, compared to the 80" screen, the 27" screen constrained the dayds, forcing them to create external representations that supported their joint problem space, rather than just spread the clues out. This led to more effective collaborative interactions, higher levels of reasoning, and faster arrival to an evidence-based solution. It is likely that dyads in the 11" condition did not create external representations because the screen was too small. Dyads in the 80" condition also did not create external representations. The screen was large enough to spread the clues and did not require them to come up with an organizing or representing strategy. These results suggest that the screen size may influence the interaction of groups, and should be considered in light of group size and task demands.

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Designing Engineering Tasks for Collaborative Problem Solving

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Abstract: Research indicates that engaging students in authentic collaborative problem solving activities can lead to increased learning and persistence in STEM. A major piece of these activities is the task. This paper describes the process of creating guidelines and using them to design three engineering tasks that support collaboration between undergraduate students. This process led to a four-step framework that can be used to design future tasks.

Introduction

Research shows that engaging students in authentic, collaborative problem solving can lead to increased learning and persistence in STEM fields (e.g. Barron & Darling-Hammond, 2008). However, although there has been an increase in the use of collaborative activities in STEM fields less attention has been paid to the development of the types of tasks for those students. In our work (Mercier, et al., 2015), we found little change in collaborative practices during four weeks of collaborative problem solving in an introductory engineering course on statics. One issue we identified was that the tasks were highly structured, algorithmic, and did not provide many opportunities for students to collaborate; interactions were often limited to checking answers. To address this issue, the research team worked with faculty, teaching assistants, and students to create guidelines for designing new tasks that are ill-structured and authentic. The process of designing these tasks is described in this paper. The process consisted of five stages that led to a four-step framework that can be used to create future tasks.

Stage 1: Reviewing relevant research

Relevant research areas were reviewed to account for what is known about collaborative problem-based learning. The first was collaborative problem solving in engineering. Successful engineers are those who are prepared to solve workplace problems. Jonassen et al. (2006) conducted interviews with 106 engineers; the responses showed that workplace engineering problems are ill-structured, can be solved in different ways, and require extensive collaboration. This research, along with work in problem-based learning (Hmelo-Silver, 2004), indicates that tasks used in engineering courses should reflect the workplace problems by having multiple solutions with multiple solution paths. This characteristic makes these tasks challenging and appropriate for collaborative problem solving.

The second ares reviewed was dimensions that may influence the difficulty level of a problem-solving task. One important factor to consider when designing these tasks is the difficulty level. Jonassen and Hung (2008) identified complexity and structuredness as dimensions that determine the difficulty level of a problem-solving task. Parameters of the complexity dimension include the amount of domain knowledge needed to solve a problem, the difficulty level of comprehending or applying a concept, the number and complexity of the steps that constitute a solution path, and the number of the relations that need to be simultaneously processed (Hung, 2016). Parameters of the structuredness dimension includes the unknown portion of a problem space, the number of possible interpretations for understanding and solving a problem, interdisciplinarity, instability of the variables throughout the problem solving process, and legitimacy of competing solutions that exist within the problem space (Hung, 2016). The researchers used the parameters of complexity and structuredness dimensions to make decisions associated with setting the objectives and content of the tasks and to evaluate difficulty level.

Stage 2: Meeting with faculty and teaching assistants

The researchers met with engineering faculty to set the goals and objectives of the tasks in relation to the learning goals for the course. Discussing the goals and objectives helped in identifying the key concepts that were used to determine the content of the tasks. Then, the researchers met with the teaching assistants to write the tasks. These meetings focused on finding real-life applications of the key concepts to contextualize the content of the tasks so that they are similar to a workplace problem, with multiple solutions and multiple solution paths

Stage 3: Iterative design of one task with stakeholders

An iterative design method was used to create the first task. After selecting the content of the task and finding real-life applications of the key concepts, the researchers wrote the task with a teaching assistant. Multiple iterations of the task were worked through by the teaching and research team.

Stage 4: Testing the task with teaching assistants and student informants

To evaluate the task, one teaching assistant solved the task and provided feedback on its length, content, clarity, difficulty, and ability to engage students' in collaborative interactions. Another engineering graduate student worked through the task, using a think aloud protocol to provide the researchers with insight into difficulties encountered in both the language and framing of the task. Finally, two engineering undergrads, who had recently completed the engineering course, worked together on the task, while being observed by the research team. Alterations were made between each pilot test.

Stage 5: Creating a four-steps framework for future task creation

Finally, a four-step framework was developed and tested while creating two additional tasks. The final framework can be used to design tasks in other disciplines. The four steps are:

1) Setting goals and objectives of the task,
2) Finding real-life applications of the key concepts associated with the task,
3) Completing the task template presented in Table 1
4) Evaluating the designed task through pilot testing.

Table 1: Sections in the task template

Section 1	Introduction	A short story that contextualizes the problem in an authentic situation. It is based on the real-life application of the key concepts. It is usually supported by figures.
Section 2	The problem	A short description of the problem.
Section 3	Your task	A description of task(s) that students are expected to achieve in their groups in order to solve the problem in a specific time.
Section 4	Supplementary material	Numbers, figures, tables, and/or any other information that the group members may need to solve the problem.
Section 5	Tools	Scaffolding tools that the group members can use to write a plan and/or sketch any diagrams to solve the problem.

Conclusions and implications

One major piece of implementing collaborative activities is the task. Descriptions of the nature of these tasks and how they should look exist in the literature; however, a description of a detailed process for designing these tasks is rare. This paper described a process that was implemented to design engineering design tasks and create a framework for future use. The three tasks that were designed were used in a recent course; after using these tasks the teaching assistants decided to use the framework to create similar tasks for later weeks of the course, providing students with more opportunities for authentic collaborative problem solving and indicating a desire to use these types of tasks in future iterations of the course.

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Designing Simulations for Evaluating Collaborative Problem Solving in Electronics

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Abstract: Collaborative problem solving (CPS) is a skill critical for the 21st century workforce, particularly in STEM fields. Assessment of CPS skill has thus received increasing attention. This paper describes a program of research in which we seek to design a suite of CPS simulation-based electronics tasks suitable for assessment use. We focus on the pilot study of one task, describing the task design and subsequent modifications implemented to better capture evidence of students' skills.

Introduction

Collaborative problem solving (CPS) has been identified as a critical competency important for the 21st century workforce (Burrus, Jackson, Xi, & Steinberg, 2013). CPS skills are particularly important in STEM fields, which often involve individuals with diverse skill sets and perspectives working together to solve a problem as opposed to individuals working in isolation. In this paper, we describe a program of research in which we have designed a suite of online CPS simulation-based tasks in the domain of electronics that 1) provide students free online access to solve real-world problems in electronics, 2) provide us a way to collect detailed data about how students work collaboratively (or not) to reach common goals, and 3) provide us the opportunity to develop methods to define and evaluate the contributions of and strategies employed by team members as they work collaboratively.

Collaborative electronics tasks

Evidence-centered design (ECD; Mislevy, 2011) was used to guide the iterative design of the simulation-based tasks. ECD provides a framework for combining domain information about the concepts covered in the simulation environment with information about the environment's specific goals, constraints, and logistics in order to create a blueprint for measuring performance within the environment.

Basic electronics provided a rich environment for study of student behaviors because 1) it is easily and efficiently represented graphically, 2) is easily simulated with minimal mathematical constraints, and 3) is directly representative of real-world activities with which students are familiar from laboratory experiences. One simulation in the suite of activities, the Three Resistor Activity, deals with the relationship between resistance, voltage, and current summarized by Ohm's Law: $V = I{\cdot}R$ (see Figure 1). Three students work as a team on separate computers, and each is provided with one simulated, variable resistor that is part of a series circuit (see circuit schematic in bottom of Figure 1). Students can measure the voltage across their own resistor (or current or resistance) with a simulated digital multimeter (DMM), and change their resistance value in an effort to achieve a prescribed "goal voltage drop." However, they soon discover that a change made to any one resistor affects the current through the circuit and therefore the voltage drop across all resistors. Thus, for all team members to achieve their goal voltage drops, they must coordinate their efforts, aided by the use of a chat box. The Activity has five levels of increasing difficulty. As students work through each level, their on-screen actions (e.g., DMM mode changes, resistor changes, calculator usage, chats) are captured, time coded, and saved as log files.

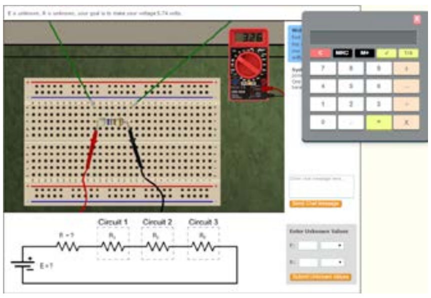

Figure 1. One student's screen in the Three Resistor Activity.

Pilot study

In a pilot study, students at a technical high school (15 teams), community college (36 teams) and public university (32 teams) participated in the Three Resistor Activity. That is, groups of three students, each located in different parts of the computer lab, were assigned to a circuit, and connected only by the chat window and the simulated wires joining their resistors. Our expectation was that students would approach the task much as they would a homework problem: determining and using the external voltage (E) and the external resistance (R_0) to calculate the resistance values that would yield their goal voltage drops, and set their resistance values accordingly. We expected either that the calculation might be accomplished by one team member and then communicated to other teammates, or that it might be reached by progressive consensus involving more than one team member. However, log file analyses indicated that this assumption was largely incorrect. Rather, many teams employed a strategy that resulted in exceptionally fast finish times (well under 60 seconds), few or no chats, and no calculations. Examining the log data revealed that, in these situations, each team member adjusted their resistance value up and down, trying to approach their goal voltage. Of course, because the resistors are connected to each other, each time one student changes their resistance and their voltage drop, everyone else's voltage drops change too. The log data showed that students simply persisted in their adjustments to their own resistance until everyone's voltages converged to the desired values. As a result, the students did not need to find E or R_0 or demonstrate any understanding of the circuit theory. Furthermore, since students who employed this strategy did not require any discussion, we were not able to capture much information about students' collaborative problem solving skills.

Closer investigation into the task design suggested that our user interface (UI) that permitted conveniently adjusting the resistance values with a horizontal "slider" actually encouraged students to scroll R values back and forth while viewing real-time changes in their voltage drop on the DMM. In effect, the log data allowed us to see that many students (though not all) demonstrated an ability to "game the system" with little or no verbal communication between themselves, and little or no application of physics knowledge. We called this a "voltage regulator strategy," since each student in effect behaved exactly as a digital voltage regulator would. In an effort to discourage this behavior in favor of more strategic collaboration, we produced a revised version of the activity, eliminating the slider, and instead requiring students to use a dropdown menu to choose a single new resistance value in order to observe the resultant voltage change. For our purposes, the dropdown menu removes the temptation for the student to simply slide the cursor back and forth in response to the voltage reading on the DMM, with little regard for the actual resistance value. By eliminating this possibility we hoped to subtly discourage them from adopting the voltage regulator strategy, and instead rely on collaboration. Additionally, for the more difficult levels we added input boxes for students to provide the E (voltage source) and R_0 (internal resistance) values. We anticipate that these UI changes will create better opportunities for us to capture information about students' content understanding and collaborative problem solving skills, as they will now presumably have more need to strategize with the electronics concepts, calculations, and discussions.

Conclusions and future work

Our pilot study has demonstrated how even very small changes in task UI can have major effects on the usefulness of a simulation-based task for assessment. Through an iterative design process, and by logging all student actions, we have been able to determine which design features create better opportunities for students to provide evidence of their skills. Currently, the revised version of the Three Resistor Activity is being evaluated to determine whether our UI modifications can better capture students' skills.

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Teachers' Cultural Competency: Media Interactive Case Studies as a Low-Stake Practice Space

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Abstract: We present early phase work on a technology-enhanced practice space for teachers called Media Interactive Case Studies (MICS). Our research aims use technology to advance innovative pedagogies in teacher education, building upon prior work in clinical simulations with live actors. In MICS, teacher candidates anticipate, rehearse and reflect on in-the-moment decisions in classroom situations. Specific scenarios target skills in cultural competency within STEM domains, and awareness of unconscious bias. Using a design-based research approach, we are investigating affordances of this technology, in alignment with the CSCL Strand 3: Equity and Access through Culturally Responsive Pedagogies, focusing on historically disadvantaged student populations.

The major issue addressed

Teachers must be prepared to consider a wide range of cultural experiences to effectively teach all students and respectfully communicate with their families (Banks et al., 2005; Gay, 2010). Teachers' cultural competency should be emphasized in teacher education because students' academic performance can be improved when teachers utilize knowledge of students' social, cultural, and language backgrounds (Banks et al., 2005). Medical training involves practicing cultural competency in high-stakes clinical simulations (Kurtz, Silverman & Draper, 2005), but Grossman and colleagues (2009) conclude that "prospective teachers have fewer opportunities to engage in approximations that focus on contingent, interactive practice than do novices in [other professions]." Even though "knowledge plus practice is imperative" for developing cultural competency (Gay, 2010), little evidence exists on how cultural competency can be nurtured in pre-service teachers (Self, 2016).

Potential significance of the work

To support teachers' development of cultural competency, structured opportunities should be provided that allow teachers to gain experience in authentic settings where they can engage in targeted deliberate practice (Grossman et al., 2009). Our innovation builds upon previous work in clinical simulations, where actors play the role of student or parent and present pre-service teachers with situations requiring thoughtful approaches to cultural skills (Dotger, 2013; Self, 2016). This is a powerful pedagogy, and we have explored adapting it to technology-enabled online simulations in an effort to lower barriers to adoption while preserving key strengths of this pedagogy.

In Media Interactive Case Studies (MICS), teachers are presented classroom scenarios with volatile moments of instruction (e.g., a frustrated female student speaks out in math class, students working in pairs exhibit power dynamics related to gender and race). These scenarios are presented as a sequence of written text or short videos (See Figure1 for an example simulation with supporting instructional design elements within curriculum).

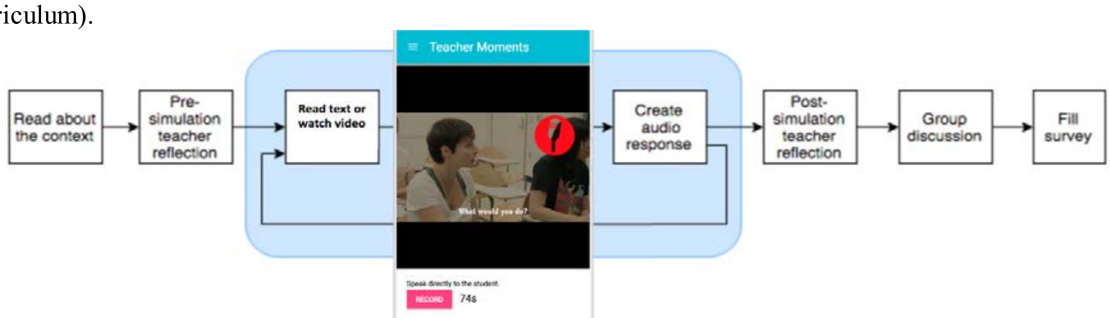

Figure 1. Media Interactive Case Studies and Instructional Design Elements.

The scenarios focus on classroom moments that can either surface teachers' frames for interacting with students, or where they can practice specific skills related to cultural competency. Teachers interact in the simulation by either speaking to students, typing what they would say, or choosing from a set of responses.

After finishing the online simulation, they may review their data of how they chose to interact, answer reflection questions, and prepare for a group discussion in person or online. Depending on how the experience is embedded in the teacher prep curriculum, they may also watch videos showing how different teachers responded in the same situation.

Theoretical and methodological approach

We use a design-based research approach (Sandoval & Bell, 2004) with iterative phases of design, development, and evaluation. MICS was created in collaboration with teacher educators and veteran teachers, and informed by literature review. We evaluated each iteration of MICS in user tests involving a mix of about 50 educators. Participants' experience were documented via observation, data within MICS, and semi-structured interviews.

Major findings

There are three major findings in the early stage of this work. First, MICS has been successful overall in immersing teachers in classroom situations, describing it as "cool to actually have the experience to respond to somebody" and "better than many other alternatives." It also generated data that was useful for formative assessment purposes, for creating a shared context around specific problems of practice, and led to productive discussion and learning about a variety of complex teaching decisions.

Second, several affordances of MICS influence how teachers experienced these online simulations and surrounding learning experiences. Audio responses were "more real" and "felt like I was talking to a student" but led to feeling "a little bit more self-conscious." Small features created friction, like a timer showing how much time passes as candidate respond, or an option to review audio responses immediately. We found that without enough context for scenarios, candidates made unexpected inferences about the context that led to confusion. Adding additional context and pre-simulation reflection questions similar to Dotger (2013) improved this, as did asking teachers to take on the role of a substitute teacher rather than building the full context of their future classroom.

Third, the experience and curriculum surrounding the online simulations influenced teachers' experience and opportunities for learning. Teachers preferred a group discussion after the experience over individual practice with immediate feedback, and this preference was influenced by which competencies targeted were in the online simulation (e.g., classroom management strategies, engagement strategies, facilitation skills during group work). Teachers also asked how this compared with "actual in-person rehearsal" and expressed interest in being able to "take some time to sort of revise how you would've [responded]" and "rehearse" more.

Implications/conclusions

This work suggests that MICS could augment teacher preparation programs, particular for skills related to cultural competency in STEM domains and awareness of unconscious bias. In particular, online simulations where pre-service teachers can anticipate, enact and reflect appear to be a promising learning mechanic. We will continue to iterate on the technology and instructional design, working closely with teacher educators to explore adapting MICS to embed it within teacher preparation programs, and to measure its effectiveness for learning.

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Laboratory of Co-Inquiry, Co-Design, Co-Teaching, and Co-Regulation (Co^4-Lab)

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Abstract: The purpose of the present poster is to introduce Co-Inquiry, Co-Design, Co-Teaching and Co-Regulation (Co^4-Lab) project (2015-2019). The project pursues a series of design experiments that engage primary and lower secondary-school students, under the guidance of teachers and researchers, in intertwined science and design processes for creating and building knowledge embedded in artefacts. The poster will introduce the framework of studying learning by collaborative making and present preliminary results of the first design experiment.

Keywords: inquiry learning, primary school, innovative design approach, learning by making

Background

The purpose of Co^4-Lab (Academy of Finland, project 1286837) is to pursue a series of design experiments for engaging primary and lower secondary-school students in collaborative creation of knowledge. Although Finnish students obtain high scores in international science assessments, their interest in science and school motivation are among countries at the lowest level. In spite of ample opportunities for pursuing creative social interests by digital technologies, most Finnish adolescents use digital tools for merely hanging out with friends or playing recreational games. Moreover, educational technologies are used for creative learning only minimally at school. In order to learn creative socio-digital practices, students need opportunities to participate in structured activities aimed at creating knowledge and artifacts. Toward that end, Co^4-Lab engages students in designing and constructing complex artifacts sparking intellectual, engineering, and aesthetic challenges, and, thereby, bringing elements of “maker” culture to school (Blikstein, 2013). Student teams participate in ideating, designing, inventing, prototyping and making various artifacts using digital and traditional tools and technologies. Co^4-Lab design experiments engage students working with complex phenomena and open-ended problems integrating several school subjects. They are engaged in use scientific concepts and models as cultural tools of investigation while pursuing science, technology, engineering, arts and mathematics (STEAM) studies. Students are guided to evaluate and test ideas by constructing sketches, models, and prototypes so as to acquire “working knowledge” of scientific principles. They prepare for possible setbacks by pursuing iterative cycles of inquiry (successive cycles of efforts correcting weaknesses and limitations). Improving and redirecting activity and identifying promising opportunities by repeated feedback (guided self-assessment; peer review, teacher guidance, expert review). They are guided to share effort by utilizing on students’ and teachers’ heterogeneously distributed knowledge and competence (distributed expertise; co-regulation). Projects are supported by conducting field studies, such as museum visits, and interacting with experts. They are encouraged to pursue innovative inquiries going to directions that are not fully anticipated by researchers.

Integrating maker activities with regular school learning is supported by Finnish exceptional craft and technology education infrastructure (every school has corresponding instruments, spaces, and classrooms as well as 2-3 weekly craft lessons). Each design experiment involves active participation of several teachers (3-5) together with researchers and other experts orchestrating and facilitating student learning. In each of four pilot schools, we organize one design experiment with multiple iterations, initially with extensive support by the researchers; the later (2nd or 3rd) ones are carried out more independently with local adaptations by teachers and schools. The initial setup of Co^4–Lab projects rely on those advanced practices of design thinking, scientific inquiry, and knowledge building that the present investigators are familiar with. The importance of students’ and teachers’ agency is highlighted by having them adapt and extend methods and practices developed according to their own experiences and interests. The present project is aimed at producing new insights concerning productive integration of school subjects for addressing complex phenomena and effective use of investigative methods for socializing students to the productive and creative use of knowledge that is emphasized by the curricula coming to Finnish schools in 2016.

Participant and methods

The first Co^4-Lab design experiment was conducted during Spring 2016 in a primary school (350 pupils) in the capital area of Helsinki, Finland. The participants were 47 students (ages 11–12) from an inclusive co-teaching class (two combined classes, nine special education students, and three teachers). The challenge was to "Design an intellectually challenging, aesthetically appealing, and personally meaningful complex artifact making daily activities easier. It could be a new or improved invention and it should integrate material and digital (e.g. circuits or robotic) elements." The project was implemented during three months and it took approximately 23 lessons, about 2-3 hours a week. The students worked in the ‘‘home teams’’ (4 -5 students) in whole class and lab environments. Data acquisition relied on a) collecting and analyzing pupils process portfolios, b) video recording whole class sessions as well as video recording of group work sessions of three student teams, c) students' written project reflections at the end of the project. Students' creative products and texts were analyzed by applying Barlex's (2007) design decision pentagon: User (i.e., who it is for); Conceptual design (what it does); Technical consideration (how it works), Aesthetic considerations (what it looks like) and constructional solution (how parts fits together). In this framework, the design is composed of a set of sub-processes linking these aspects together. Further, for video analysis the content logs were created in order to analyze two team's the group work sessions.

Preliminary results

The given design challenge was very broad and included only one requirement: "It could be a new or improved innovation and it should integrate material and digital (e.g. circuits or robotic) elements." The making activity was structured according to several stages, including skill building (programming and working with GoGoBoard circuit board), orientation (visiting designer guided analysis of existing artifacts), brainstorming design challenges (at classroom and home with parents), design constraints (clustering design ideas and identifying promising ones), co-design (making decisions of teams' design projects and analyzing requirements), exhibition (sharing design ideas at classroom and getting feedback), knowledge seeking (vising in technical or design museum), co-inquiry (experimenting design solutions), making lab (constructing prototypes), final exhibition (group presentations to students and parents). The analysis of 13 student teams' design revealed that the details of their innovations varied a lot. Further, the inventions were categorized as a) behavioral creative designs representing an original solution to a known problem, b) functional creative designs adapting a known solution to a new problem, c) structural creative design, which modifies features of a known solutions and d) routine designs that were not considered creative. The 13 student teams came up very wide-ranging variety of innovations: from ordinary Key rack idea to Ectro – Alarming key and bus card locker with alarming sensors. The original ideas to known problem were, for example, vacuuming carpet to hallway or cord/ cable loccer. More adaptive solutions were gel comb for boys' hair and toothpaste pump bottle. Gel comb was designed so that your gel comes directly to the hair and user's hands will not get dirty whereas in toothpaste pump bottle the toothpaste were pumped on the toothbrush easily without mess. Variant solution varied the attributes of a known solution such as garbage container with alarming system and snack vending machine. In the alarming garbage container was built in sensors that tells when it is almost full. Two of the teams' ideas were quite unfinished and two teams' solutions were considered as routine solution.

Concluding remarks

In order to empower teachers' and students' agency, the first DE was co-configured rather than dictated by the researchers. The experiences of the fist design experiment are encouraging. The student teams were motivated and invested great deal of efforts to pursue their co-invention projects. Special education students participated productively in co-invention activities. The design challenge was, however, very open and resulted in a wide variety of invention project, some of them not feasible. When continuing DEs, we will guide teachers to come up with more constrained and focused design projects. Some student teams could have benefitted from more direct teacher guidance. The first DE is continuing in terms of the teams using 3D printing to make prototypes of their designs and exploring entrepreneurial possibilities of their inventions. Together with teachers, Co^4-Lab researchers are developing pedagogic models and guidelines for facilitating collaborative design and inquiry practices at elementary and lower-secondary education.

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Cultivating a Culture of Learning to Foster Socioscientific Reasoning

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Abstract: We suggest to employ Knowledge Community and Inquiry (KCI) features to support an internal-value-based culture of learning and subsequently socioscientific reasoning. A potential to support internal-values of learning was found in a first iteration of an existing module dealing with a socioscientific issue, but students did not improve their socioscientific reasoning. We present design revisions made for a second iteration, which use KCI features to foster students' internal-values learning and ultimately, their socioscientific reasoning.

Keywords: Socioscientific reasoning, learning culture, internal values of learning, Knowledge Community and Inquiry, conjecture mapping.

Introduction and background

This study builds upon an existing Web-based Inquiry Science Environment (WISE) module that engages students in inquiry and decision-making in the context of the socioscientific issue (SSI) of asthma in the community (Tate, Clark, Gallagher, & McLaughlin, 2008). Successful negotiation of SSIs requires students to develop a set of thinking practices defined as socioscientific reasoning (Sadler, Klosterman, & Topcu, 2011). These include: (1) recognizing SSI' inherent complexity, (2) analyzing them from multiple perspectives, (3) appreciating the need for their ongoing inquiry, and (4) employing skepticism about potentially biased information. Developing these skills has been found to be challenging for many students. The current research seeks to explore means for supporting students in developing such socioscientific reasoning.

Our basic assumption is that students' active participation in socioscientific inquiry as part of a community that cultivates internal-values of learning, will support the development of socioscientific reasoning. This assumption is based on research showing that students' deep learning of scientific content requires a learning environment that promotes internal values of learning (Sagy, Kali, Tsaushu, & Tal, 2016). According to this research, cultures of learning are characterized on a continuum (the Cultures of Learning Continuum—CLC) between internal and external values. Dimensions relevant to this study are: (1) attitude toward authority (internal values are associated with considering various sources, not necessarily authoritative); (2) knowledge judgement (treating new knowledge critically, rather than accepting knowledge as is), and (3) attitude toward uncertainty (viewing uncertainty as an opportunity for learning, rather than an intimidation).

To cultivate such a learning culture, and ultimately, to foster students' socioscientific reasoning, we adopt the Knowledge Community and Inquiry (KCI) approach (Lui & Slota, 2014). KCI supports scaffolded inquiry and collaboration within a learning community. Students engage in ongoing inquiry while continuously contributing to a collective knowledge-base, which serves the community' subsequent inquiry. This process, supported by technology, includes complex forms of interactions within and between groups, while students engage in reflection, critique and discourse (Lui & Slota, 2014). In this way KCI enables the inclusion of the multiple viewpoints and voices within the community, thus, adhering to the conference theme.

Design and methods

To represent the various types of conjectures in our research, we used Sandoval's (2014) conjecture mapping technique (Figure 1). The high-level conjecture was embodied using technology-enhanced features that employ the KCI approach, to support students' inquiry of the multi-perspectives involved in the asthma SSI. Our design conjecture was that the resultant design will facilitate the emergence of an internal-value based learning culture. That is, we postulated that by participating in collaborative inquiry activities, students will critically consider various sources of information and the multiple viewpoints brought by the other students regarding the asthma problem. We also assumed that these activities will encourage students to acknowledge the inherent uncertainty involved in the asthma SSI. Our theoretical conjecture was that this emergent learning culture will mediate the development of the four dimensions of socioscientific reasoning (Sadler et al., 2011). In other words, students will become more aware of the complexity and the multi-perspective nature of the asthma problem, develop an understanding and appreciation of the ongoing inquiry involved, and develop their ability to employ skepticism about potentially biased information. (Figure 1).

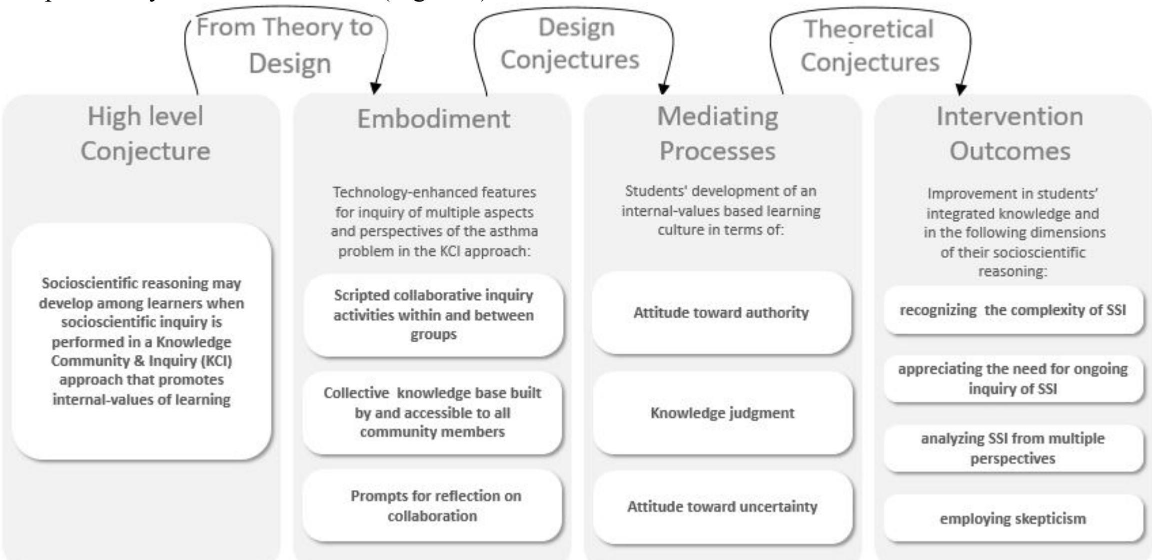

Figure 1. Conjecture mapping of the research.

We implemented the original module as a first iteration during the 2015/6 schoolyear for six weeks (twelve hours) in two 8th grade classes (65 students). Students' socioscientific reasoning and integrated understanding were analyzed using validated questionnaires and scoring rubrics (Tate et al., 2008 for knowledge integration and Sadler et al., 2011 for socioscientific reasoning). Learning culture was assessed using a reflective questionnaire and interviews that were analyzed using the CLC rubric (Sagy et al., 2016).

Preliminary findings and implications for the second iteration

Preliminary findings from the first iteration revealed that students significantly improved their integrated understanding of most tested aspects of the asthma phenomenon. However, no significant change was found in students' socioscientific reasoning. The analysis of the learning culture indicated that the module has the potential to increase internal values, but that this potential was not fully exploited in the first iteration.

Following the above findings, and in order to improve the intervention outcomes we made the following design revisions, employing our conjectures (Figure 1): (a) **Scripted collaborative inquiry activities within and between groups**—inquiry activities that were conducted in pairs in the first iteration, were redesigned as collaborative scripts within and between groups; (b) **Collective knowledge-base built by all community members**—we implemented CSCL tools that enable students to collaboratively build, improve and use a collective knowledge-base; (c) **Prompts for reflection on collaboration**—we embedded scaffolds for reflection throughout the learning process regarding students' own contribution to the community's collaborative inquiry process. We strongly believe that the refined design with KCI features will foster an internal-values based learning culture, and subsequently, will result in improvement of students' scientific knowledge and socioscientific reasoning.

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Increasing Access and Engagement Through Iterative Design

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Abstract: In this poster presentation we describe methods and data used to increase access and engagement through our iterative design and development process for PurpleState Solutions. PurpleState, a Virtual Internship that utilizes an immersive computer supported collaborative learning environment (Shaffer, 2006), places students in the role of interns at a strategic communications firm. The goal of the simulation is to increase students' skills and knowledge needed to engage actively as democratic citizens in the current media driven US context. Here we describe the iterative design model that allowed us to reach our goals of maximizing access and engagement through utilizing data gathered in the online environment.

Introduction

The use of role-plays and simulations in civics and government classes is far from new. However, opportunities to participate in high-quality simulations are often limited to more affluent populations, used as part of AP Government Courses (e.g., Parker, et al., 2013), or are limited by the digital divide in terms of access to these high-quality learning environments (Margolis, et al., 2008). Also, these simulations often model official roles within the government hierarchy, or are designed to align with state standards and textbooks rather than reflect the dynamic nature of how government processes occur that may be more relevant for students from marginalized backgrounds (Raphael, et al., 2011). These simulations also do not necessarily model the dynamic and media rich world in which today's citizens inhabit (Stoddard, 2014). This poster describes the development process of PurpleState Solutions, a Virtual Internship simulation focused on developing student skills, knowledge, and values related to media and civic education (Gould, 2011). We focus here on an design-based process over three iterations to increase access and engagement.

Theory and design framework

PurpleState was designed using the model of Virtual Internships developed by Shaffer (2006) that employs epistemic frames and communities of practice from professions as models of learning. The Epistemic Games Group at the Wisconsin Center for Education Research (UW- Madison) have developed Virtual Internships modeled on the work of engineers, journalists, and urban planners. For PurpleState, student interns collaborate to learn core concepts and skills related to political communications, research a controversial public policy issue (e.g., fracking), and then develop a media campaign to help PurpleState voters based on their assigned client (i.e., one of two opposing special interest groups). All activities take place in WorkPro, an online productivity suite that includes email and chat functions, a notebook, and all the tools and resources that students need to complete the internship. Students use WorkPro to interact with other students in the simulation and also their supervisor and online mentors. For example, the supervisor sends tasks to students and evaluates their work products; the mentor answers questions, offers suggestions, guides reflective conversations, facilitates team collaboration, and provides support. The WorkPro online environment was developed by the Epistemic Games Group and is now available to others to design simulations as part of their NSF supported authorware project.

Methods and design process

We worked closely with teacher-collaborators, content and design experts, and professionals from the field for this design-based research (Brown, 1992; Dede, 2004). A design-based approach allows for ongoing development of the simulation in response to the data being collected live in the WorkPro environment. A design-based research model resulted in a more robust simulation and a broader array of rich data for measuring the effects of the simulation. We implemented the simulation in three iterations from 2016 to 2017. With these iterations were also three rounds of data collection, analysis, and simulation revision to attempt to reach our goals of maximum participation and engagement through making the materials and simulation structure as accessible as possible.

We utilized data collected in the WorkPro environment, including team chat data, task deliverables (assessments), and descriptive statistics generated on task completion, the breakdown of individual participation in team chats (by % of utterances), as well as data from our mentors and our teacher collaborators. We used this data to identify: 1) tasks, interactions, or instances in the simulation where students were confused, frustrated, or spending a significant amount of time on trivial tasks, 2) any technical or structural issues with the simulation that could be addressed, 3) assessments that had common misconceptions or were completed poorly consistently, and 4) mentor-intern and intern-intern interactions in chat that were on the high or low end of engagement and quality of substantive conversation measures (Newmann, King, and Carmichael, 2007). In the final round of implementation, which was done with 9th grade rather than 12th grade students, we also engaged in a higher and more frequent level of continuous interaction with our collaborating teacher to identify students who seemed disengaged, frustrated, or who were struggling so that we could collaborate to support the students' successful participation in the simulation.

Results and implications

Utilizing data generated in WorkPro, we identified several areas for revision to increase access and engagement in each round of implementation. After our first implementation, we adjusted: wording in emails and task descriptions, rubrics for feedback and instructions for mentors, discussion questions and prompt scripts for mentors to support greater participation (e.g., more explicit questions to guide student thinking), and the elimination of tasks or the implementation of tasks that were not core to the intellectual work (e.g., parts of tasks that caused confusion but were not necessary to the main goal). These changes resulted in reduced confusion and higher levels of engagement (in the form of more equal levels of participation in the chat discussions) among team members. During the second implementation, we identified additional areas for revision, including refining discussion questions, creating training and scripts for online mentors to help them provide more aggressive supports, and the need to make simulation resources more aligned with the tasks and to attempt to reduce the reading level and amount while maintaining the level of sophistication. During the final round of implementation, we focused our revisions on making the role of the online mentors more active during the sessions, providing daily tip sheets and scaffolding ideas for mentors and the collaborating teacher to employ based on needs that were identified, and implemented more individualized student support both online in the simulation and in the classroom through our collaborating teacher. The poster presentation will illustrate our methods, process, and findings and the resulting simulation revisions over three iterations of development as a model for other simulations to apply in similar design-based research projects.

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Tablets in the CSCL Classroom: A Lens on Teachers' Instrumental Geneses

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Abstract: Most educational research on tablets in schools seeks to find out whether children learn more efficiently with or without such devices. This study differs from such research as it instead investigates *how* tablets take part in the everyday CSCL classroom? Grounded in the instrumental genesis theory, this study focuses on the multifarious relationships between teacher-tablets-learner(s) to inform the processes of tablet appropriation in the classroom. Analysis of the instrumental processes observed reveals that *learners* on the one hand develop usage schemes that challenge those developed by the teachers. *Teachers* on the other hand are forced to review their competence, rethinking power-relationships vis-à-vis learners and have to reflect/design a creative, critical and participatory pedagogical practice that is aligned with learners' utilization schemes and the instruments they bring to our contemporary classrooms.

The study of technology in educational research

In CSCL, there is a compelling body of research on how learning and teaching practices are reflected in CSCL artifacts and how CSCL artifacts configure our practices (Lonchamp, 2012, Ritella and Hakkarainen, 2012, Cerratto-Pargman et al. 2015, Nouri and Cerratto-Pargman, 2016). Inspired by this research that strives to provide us with accounts of unexpected use of technologies in educational institutions, this paper presents a long-term study on the use of tablets in primary schools. Drawing on the instrumental genesis theory (Rabardel, 1996, Lonchamp, 2012) the goal of this paper is to account for how media digital tools such as tablets participate in the everyday classroom. More specifically, the question that we address in this paper is: how do teachers and learners appropriate the tablet as an instrument for achieving their purposes at school? The study argues for an account of technology use that seeks to unveil the complex and dialectical path that characterizes the elaboration of teaching and learning instruments in everyday school activities.

The instrumental genesis theory

Introduced by Lonchamp (2012) into the CSCL community, Rabardel's instrumental genesis theory (Rabardel, 1996) contributes with a relational lens on the CSCL discourse on artifact apporpriation. Grounded in constructivist epistemologies the instrumental genesis theory considers that the *instrument* is a mixed entity constituted by the artifact, the material or technical part (i.e. its design and affordances) and the subject's utilization schemes or behavioral part (i.e. user's representations, knowledge and practices). Central to the understanding of Rabardel's instrument is that an artifact becomes an instrument through developmental transformations of both the artifact and the user's utilization schemes (Cerratto-Pargman, 2000, 2003a,b, Cerratto-Pargman, 2006, Cerratto Pargman et al, 2015). The instrumental genesis entails the study of a "double-development movement" between two sub-process:the *instrumentalization* process that is artifact-oriented and concerns the evolution of the material side of the instrument (i.e. new functions attributed to the artifact) and the *instrumentation* process, subject-oriented and relative to the emergence and evolution of the utilization schemes (i.e. emergence of a new activities and practice due to change in user's behavior). This study has in particular emphasized the study of instrumentation processes through the identification of user's utilization schemes.

The study: Context and participants

We carried out an empirical and qualitative study in four elementary schools located in the Northwest suburbs of Stockholm and in the city of Växjö in south of Sweden. All schools took part in the one-to-one tablet program initiated in 2011 by their respective municipalities. This program consisted of providing schools with wireless tablets computers (i.e. ipads and chromebooks) and connectivity. All the schools selected for this study actively work toward the inclusion of children into the Swedish society.

Data collected and data analysis

We collected 24 interviews with teachers (i.e. one hour and a half each) and 31 field notes from the classroom observations, which were analyzed following content analysis principles (Hsieh and Shannon, 2005). The data analysis was recursive, and has taken account of the relational character of the data, the political nature of data interpretation and the role of the researcher as "acknowledged participant" in the "production of always partial knowledge" (Clarke, 2005).

Implications

This study shows that tablets participate in the classroom in multiple ways. Teachers and learners elaborate individually and collaboratively diverse instruments. In this elaboration of instruments or instrumentation processes tensions arise (Rabardel, 1995). *Firstly*, learners develop usage schemes that challenge those developed by the teachers; situations where the learners teach the teachers how to operate the tablet, emerge. Learners' development of instrument-mediated action schemes, come to challenge teachers to rethink about the relationships they entertain with the learners and, in particular, to reconsider learners' agency and/or their own agency in the tablet-mediated collaborative learning classroom tablet. *Secondly*, teachers develop different types of utilization schemes that get reflected in the instruments they elaborate as they attempt to construct valuable epistemic and interpersonal instruments for the learners. Teachers are as such forced to review their competence, to rethink about power-relationships vis-à-vis learners and reflect/design pedagogy aligned to learners' utilization schemes and instruments. In this context, issues revolving around negotiation of teaching practices arise. *Thirdly*, the use of tablets in schools take part in an ecosystem of analog and digital artifacts that characterize contemporary classrooms.

These are exciting times for Swedish schools that are already engaged in the process of digitalizing teaching practices. Teachers' instrumentation geneses are configuring conditions for a new pedagogy associated to mobile devices. Will we end up in a critical, creative and participatory pedagogy? It seems that the question is up to what types of teaching instruments teachers will be able to elaborate and how ready they are to recognize the ample spectrum of utilization schemes children bring nowadays in to schools.

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Context and Collaborative Problem Solving (CPS): The Development of Observable Signifiers to Inform the Design of CPS Learning Analytics

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Abstract: Collaborative Problem Solving (CPS) is a key skill for the modern workplace. We do not, however, have widely accepted ways of assessing and monitoring CPS to inform educators and learners and enable the provision of effective support. This paper reports the findings of an empirical study involving 15 school students aged 14-15 years taking part in a 2-day Hack Event. The analysis identifies the observable signifiers of CPS and offers a step towards the design of automated data capture protocols and CPS learning analytics.

Introduction

Collaborative Problem Solving (CPS) is a term that is increasingly used to refer to *the process of a number of persons working together as equals to solve a problem* (Luckin et al., in press). It brings together thinking and research about the separate topics of 'collaboration' and 'problem-solving', both of which have a substantial research history in their own right. The changing needs of the workplace, the recognition of the increasing importance of what are often referred to as 21st-century skills, and the continuing development of international comparison studies, such as the OECD PISA evaluations, have prompted intensified interest in CPS (OECD, 2015). We do not, however, have widely accepted ways of assessing and monitoring CPS to inform educators and learners and enable the provision of effective support. The PELARS project is exploring the design of learning analytics to support CPS in project-based learning settings. As part of this research, it is essential to identify the observable signifiers of effective CPS and to specify if and how the capture and analysis of these signifiers can be automated. Our driving research question is: *How can we assess the effectiveness of a particular instance of CPS to inform the future design of learning analytics and software scaffolding?*

Methodology

We use the Ecology of Resources (EoR) model and a framework to analyse data from group interactions to identify CPS processes (Luckin, 2010), complemented with the work of Chi et al. (2012) to categorise the processes of CPS identified through the EoR-Chi framework. The analysis framework, which we used to code the interaction data collected in the study we report here is illustrated in Table 1.

Table 1: The EoR-Chi Framework for Analysis

Code	Code Name	Definition
0	Non-available	The resource exists within the learner's context but is not in the learner's service.
1	Available	The resource is in the context of the learner, yet the learner is not engaged with it.
2	Passive	The resource is in the context and the learner pays attention to it.
3	Active	Learner pays attention to the resource and physically interacts with the resource.
4	Constructive	Learner pays attention to and physically interacts with resource, generates knowledge for self.
5	Interactive	Learner pays attention to and physically interacts with a resource, generates knowledge for self and helps others generate knowledge.

The empirical study: The Education Hack 2015

15 students aged 14-15 years, none of whom had previous experience with the study technology or activity. Over 10 hours of video was coded by two researchers according to the EoR framework and the EoR-Chi framework. The coding was completed from the perspective of each individual learner. Resource use was recorded at 30-second intervals. The two researchers discussed all disagreements and reached a consensus.

Results

Figure 1 presents a comparison of the total resources used by all groups of learners over the same 1-hour period of the hack event. It clearly illustrates the differences between the groups. For example, the group developing the glove prototype made greater use of the adult resources available and of the technology. They also interacted with the prototype. By comparison, the coin sorter group used each other and made heavy use of paper and instructions. They used the prototype components but had no prototype to interact with at this time.

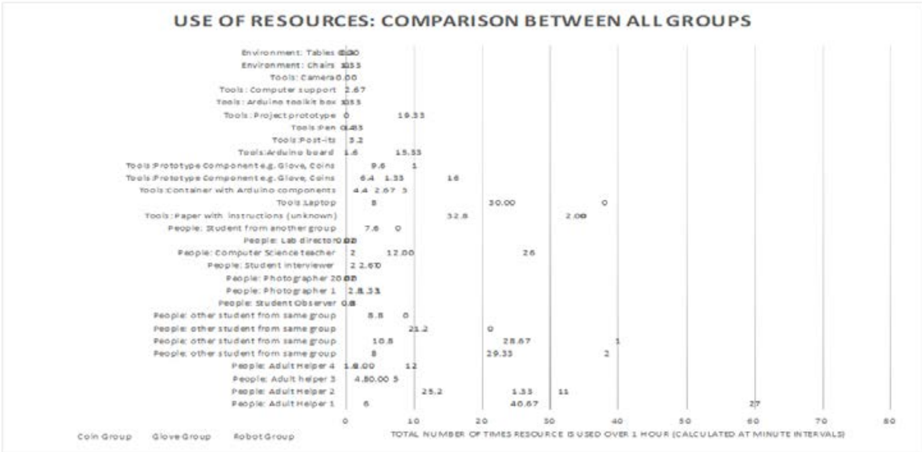
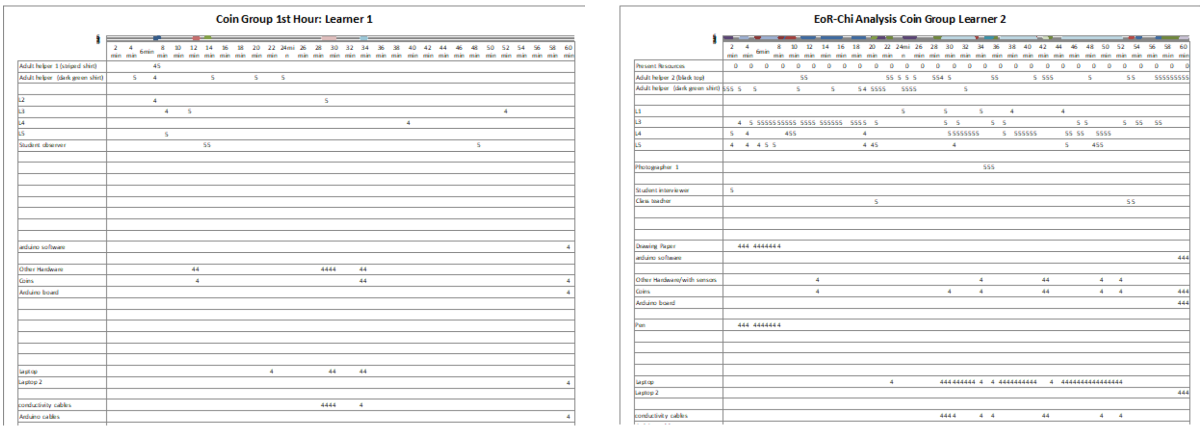


Figure 1. Comparison of resource use by groups of students.

The EoR-Chi analysis for L1 and L2 as illustrated in Figure 2a reveals that there is only 12 minutes, which is less than 20% of the hour-long session in which L1 interacts at EoR-Chi levels 4 or 5. This suggests that L1 engages in limited higher order interactions in this particular hour long session of the Hack Event. By contrast, L2, as illustrated in Figure 2b, interacts at EoR-Chi levels 4 or 5 for 53 minutes (89%) of the session.



Figures 2a (L1) and 2b (L2). The EoR-Chi levels 4 and 5 analysis for L1 and L2 from the Coin group.

Our results using the EoR-Chi framework show that both individual students and groups of students present different patterns of engagement with the human and tool resources around them during practice-based learning activities. We argue that these differences between the groups and individual students' use of resources may indicate their different degree of engagement with the CPS process.

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Girls, Robotics Learning, and Internalized Stereotypes: Is There a Relationship?

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Abstract: We investigated the incidence of negative verbal attributions of ability as girls participated in a robotics workshop. Video data were collected. Participants were 17 girls, ages 8-13 (M = 11.725). Our analysis indicates that the all-girl groups do use negative internal attributions to describe their own robotics activity. However, the overall incidence of these attributions are miniscule as a percentage of overall talk, indicating a negligible role for internalized stereotypes in girls' learning with robotics.

Given the dearth of women pursuing computer science (CS) degrees and careers (National Science Foundation, 2015) and the fact that early experiences with technology are important to future pursuit of CS (Margolis & Fisher, 2002), as well as the findings related to the role of stereotype threat (Steele & Aronson, 1995) in affecting performance for women, we investigated the role of negative internal attributions of ability as girls' participated in robotics learning. Our goal was to understand if negative stereotypes about women's technology ability surface for girls during robotics participation. To investigate this question, we performed sentiment analysis (Liu, 2010) on five hours of student talk as girls solved robotics problems. Furthermore, we used Rotter's (1966) construct of internal and external locus of control (LOC), defined as a generalized expectancy regarding the source of control for certain events, to determine girls' view of their own efficacy with robotics.

Methods

In this observational case study, we collected video and audio data as participants took part in a day long, all-girl introduction to robotics event. The participants in this study included 17 girls, ages 8-13 (M = 11.725). Fourteen of the participants identified as ethnically white, and three as Latina. A total of eight video cameras and 17 wireless microphones were used. All of the interactions of each group were video and audio recorded over the day long activity, resulting in five hours of talk from each group. Audio data were fully transcribed. We used a modified form of sentiment analysis to determine positive and negative attributions identified in the text. Sentiment analysis requires a researcher to develop a list of terms with positive or negative valence for a given context (Wilson, Wiebe, & Hoffman, 2005). Because we were interested in the role of internalized stereotypes, we chose to focus on the incidence of negative attributions across the six groups. Once we had identified utterances containing terms with a negative valence, we counted the frequency of such attributions per group. Next, we lexically identified the locus of control for each negative attribution (e.g., internalized attributions will feature the pronoun "I" or the possessive pronoun "my," whereas external attributions feature the pronoun "it"). We then counted the total number of negative attributions and we counted the number of internal vs. external references.

Results and discussion

Table 1 presents the results of our sentiment analysis of negative attributions and the locus of control for these attributions by group.

Table 1: Negative Attributions and Locus of Control by Group

Groups	Total Utterances	Negative Attributions	Internalized LOC	Externalized LOC
Green	2693	15	6	9
Dark Blue	3212	23	6	17
Yellow	3588	63	38	25
Dark Gray	3776	22	9	13
Light Blue	4063	41	11	30
Light Gray	4379	54	19	35

As can be seen in Table 1, negative attributions were either a fraction of a percent or a very small percentage of overall comments in every group. Moreover, with the exception of the Yellow group, the girl participants were more likely to make attributions with an externalized locus of control. This seems to indicate that the girls did not view their own ability as the sole source of difficulty, frustration or failure with the task, but rather attributed such, more often, to external aspects of the activity. To further understand the nature of these data, we provide examples of both internalized and externalized locus of control comments, drawn from each of the groups in Table 2.

Table 2: Examples of Negative Attribution/LOC by Group

Groups	Internalized LOC	Externalized LOC
Green	*I hate it when I do that.*	*Otherwise, it might be ugly.*
Dark Blue	*I'm too bad at this.*	*See this is what boredom does to one.*
Yellow	*I just don't really like…whatever I'm doing, I'm just like I'm out of here.*	*Stupid thing.*
Dark Gray	*Because I'm good at it? I'm horrible at it.*	*I know it's getting me frustrated.*
Light Blue	*I'm bad at reading the labels. Like I get them and then I forget the other half.*	*We just swapped that one because it was really difficult.*
Light Gray	*I'm kind of worried about the programming? Whatever we do it doesn't seem to work. Fail, fail, we failed again.*	*Go, there go, do it, do it. You stupid plough.*

It is important to note that all of the girl participants opted in to this study and wanted to study robotics. Therefore, this is not a particularly representative group of middle school aged girls. Also, it is not clear how the gender exclusive nature of the activity affected the girls' experience. For example, if the workshop had enrolled equal number of boys and girls, would the salience of negative stereotypes about girls and technology been greater, and would that have had a negative effect on the girls? Prior research suggests this would be the case (Steele & Aronson, 1995). That said we view these findings as very encouraging. It appears, in our study, that the girl participants do not seem to have internalized negative stereotypes about women/girls and technology ability.

Future research should examine if and how negative stereotypes may, yet, impinge on girls' efficacy in robotics learning environments. For example, does the mere presence of boys in a robotics setting affect how the girls feel about themselves? What would the impact of an all female teaching team have on a gender inclusive robotics workshop for middle school aged students? Research on these questions will aid us in continuing to support girls who are interested in pursuing technology studies.

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Framing the Design Space for Mobile Facilitation Tools in Exhibit Settings

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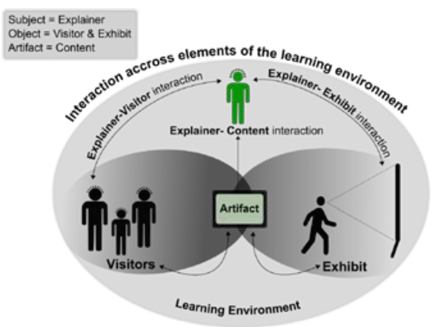
Abstract: Informal science education institutions, such as museums and zoos, have begun exploring the use of mobiles not just to deliver content directly to visitors, but as supports for interpretive staff (e.g., explainers, docents, interpreters, or tour guides). We employed socio-cultural theories to define the problem space found when designing mobile tools to assist explainers. Unique usability challenges arise when one recognizes that explainers use mobile devices foremost as tools that mediate their other interactions in the space. Our framework highlights three key mediated interactions that designers should attend to: interactions with visitors, with content, and with the exhibits themselves. The challenge of designing a single mobile tool that can support all three meditational functions is illustrated via an account of the evolving design of such a tool constructed in partnership with a local zoo. By using a design-based research methodology, this evolution allows us to reflect on the implications for designing support tools for interpretive staff.

Introduction

An explainer generally serves as the human face of Informal Science Education Institutions' (ISEI) educational mission, by helping visitors use exhibits and understand content more deeply. ISEIs have begun incorporating custom and third-party software for tablets and smartphones into their interpretation, which raises both new opportunities and new challenges, especially for novice youth and volunteer explainers (Owen et al., 2009; Roholt & Steiner, 2005). Explainers are responsible for managing an entire system of interactions based around their relationship with visitors, technology, tools, exhibits, and educational content. Few studies have explored the potential of mobile technology for supporting explainers. When explainers have used technology, they are often re-appropriating tools designed with visitors, like the PDA-based *Mobile Electronic Guidebook* (Hsi, 2008) or the *Science On a Sphere* tablet controllers *(1)*, or existing iPad applications as in the 21-Tech project *(2)*. We argue that explainers comprise a unique population with unique usability needs. The purpose of this research is to take the first steps towards answering the question: what is the problem space involved in designing mobile tools that support explainers' ability to engage with visitors?

Theoretical framework

Mobile technology offers many affordances for supporting learning activities in museums, but prior work has predominantly considered visitors to be the primary user population (Lyons, Becker, & Roberts, 2011). By drawing on the theoretical concept of mediated action (Vygotsky, 1978; Wertsch & Rupert, 1993) to cast interpreters as the mediational "subject" (rather than visitors), we open up a new perspective on how tools can be designed, highlighting potential areas of tension arising from competing attentional, social, and structural demands.



Interactions directly mediated by mobile interpreter support tools:

Explainer-content, which includes: locating content, displaying content, matching content to exhibit state, matching content to visitor interests

Explainer-exhibit, which includes: operating the exhibit, detecting state of exhibit

Explainer-visitor, which includes: eliciting visitor interests and experiences, delivering educational themes and goals, delivering salient content given exhibit state, answering visitor questions, provoking visitor questions

Interactions not directly mediated by mobile interpreter support tools:

Visitor-content, which includes: reconciling new information with prior understanding and experiences, generating questions to ask interpreter

Visitor-exhibit, which includes: detecting state of exhibit, operating the exhibit, forming experiential memories

Figure 1. Framework for Technologically-Mediated Interpretation.

This framing emphasizes not just the affordances and constraints of a particular tool, but also how that tool acts as an artifact mediating these pre-existing relationships. The concept of "mediation" is used to describe the ways in which the presence of some tool—in this case, the one we designed and introduced—is able to create new possibilities for the subject (explainer) to act on and relate to the object (here, either the visitor or the exhibit itself) (Vygotsky, 1978).

Key relationships in our target exhibit

Our testbed exhibit, *A Mile in My Paws* – ("Paws"), is a digital exhibit that served to highlight the emerging issues and challenges encountered by explainers when mobile support tools were incorporated in their interpretation task (Jimenez Pazmino et al., 2013). This study was performed in 2 iterations: a baseline case with the first design of the tool (a full day of using the exhibit – 45 trials), followed by a second iteration with a revised version of the tool (3 subsequent days – 38, 12 and 3 trials respectively). The study involved 15 novice explainers. The data gathered includes: researcher field notes, and 27 individual interviews with explainers. Qualitative observations of use, and some quantitative measures of interpretation were used to better understand how the mobile tool did or did not mediate the different interaction relationships in the problem space. In the baseline case, where explainers chose content from a list of media, the exhibit's educational goals were neglected in favor of visitor interests, explainer's personal recall, and multimedia "favorites." To support the explainers, we wanted to streamline the *explainer-exhibit* and *explainer-content* interactions by automatically monitoring exhibit events and suggesting relevant content to present to visitors. So the second iteration used a prompt-based approach to help the explainer keep discussions going with visitors (*explainer-visitor* interaction) with the minimum of *explainer-exhibit* "overhead" (no exhibit monitoring required: the system automatically selected content relevant to the current exhibit state). The prompts also helped explainers to deliver more content to visitors (measured by the % of available content logged as displayed to visitors).

This approach uncovered some challenges with: 1) overdependence on prompts, 2) attention management, and 3) social management. Although the second iteration facilitated the *explainer-exhibit* relationship by offloading monitoring, and the *explainer-content* relationship by improving explainers' coverage of educational content, the design made attending to and "obeying" the prompts almost too easy, reducing the discretion explainers used in managing *explainer-visitor* interactions with a large crowd and attending to visitor interests. This shows how facilitating some relationships can inadvertently impact others, suggesting that mobile interpretive tool designers should consider less "efficient" facilitation designs when those inefficiencies can help balance the inherent tension between these different interactions.

Conclusions

This work presents a framework that defines the problem space for designing mobile tools to assist explainers. One tension this framework reveals is the need for explainers to divide their attention between their interactions with *visitors*, with *content*, and with the *exhibits*. We have just begun exploring this design space, but we believe we have framed the problem space in a useful way, and exhort other researchers to start examining some of the issues we have outlined.

Endnotes

(1) Institute for Learning Innovation. (2010). Science On a Sphere: Cross-site summative evaluation. Retrieved from http://www.oesd.noaa.gov/network/SOS_evals/ SOS_Final_Summative_Report.pdf
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Distributed Teaching and Learning in Pokémon Go

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Abstract: Pokémon Go is a popular 2016 game released for mobile devices. The game uses GPS to track players' locations, as well as the cameras on phones to superimpose game elements onto real-life settings. While the game has garnered attention from researchers and the public alike (and speculation about its potential for learning abounds), little empirical research has been performed around the game. This poster is an overview of a mixed-methods study of players in one community.

Distributed teaching and learning

In this study, I used the framework of affinity spaces (Gee, 2004) to examine learning around the game Pokémon Go. Affinity spaces are informal learning communities which are formed around a common passion or interest. Affinity spaces, particularly those around video games, have been framed as sites for deep learning and engagement (Gee & Hayes, 2010; Curwood & Alecia Marie Magnifico, 2012; Martin, 2012; Duncan & Hayes, 2012). These spaces are often conceptualized as being bounded within a particular site (such a website or forum); however, a number of scholars have noted that the learning around affinity spaces is often distributed across multiple sites, e.g. Martin (2012).

Building on this notion of the distributed nature of teaching and learning around affinity spaces, a number of scholars (Gee & Gee, 2015, Homes, 2015; Holmes, Tran, and Gee, 2017) have developed a model of *distributed teaching and learning systems*. This framework attempts to describe the myriad complex practices of learning in informal environments, including the ways in which learners navigate between sites and spaces and manage the vast array of information available to them. Another important aspect of this framework is an emphasis on teaching as well as learning. As learners in informal environments often rely on peer-created resources such as tutorials, YouTube videos, and wiki entries, the creation of these resources represent acts of teaching which are equally as deserving of analysis as learning.

Pokémon Go teaching and learning

As the game is a recent phenomenon, little empirical research exists around the game. In this study, I explored the question of how players of the game navigate a network of distributed information, as well as the ways in which players gather information and apply it to their own gameplay.

This game, in particular, is a good example of this distributed teaching and learning for several reasons. One, the gameplay is based on location. This element is unlike other multiplayer games which have been heavily researched, such as *World of Warcraft* and *Second Life*. In those games, physical location is no barrier to playing, and hence players can interact with other players from all over the world. The unimportance of physical location is also a key characteristic of affinity spaces (Gee, 2004). However, in Pokémon Go, this is not the case. Players' geographic region determines which Pokémon they can catch, what territory they will be able to control, and where they can acquire items and resources.

As such, players primarily interact with other players from the same area. Online, instead of going to more general sites about the game, players often visit resources specific their regions. These resources include websites, Facebook groups, subreddits, and other social networks. Players also arrange meetups with each other in order to play together and share information. In this study, I "follow" players between these real-life and virtual spaces in order to understand how players teach and learn around the game. Players tend to be cooperative and collaborative, especially in real-world settings. There is no immediate scarcity of Pokémon; that is, if one player finds and catches a Pokémon in an area, all other players will also be able to capture that same Pokémon. As such, players are not competing over the Pokémon they find, and it is common for players to call out locations of rare Pokémon they find or set up items to attract Pokémon which benefit all players in the area.

Another reason that Pokémon Go is a particularly interesting game through which to examine informal distributed teaching and learning is the lack of designed teaching in the game. There is no in-game tutorial, and there is very little explanation of what the goals and mechanics of the game are. It might appear that there is not much complexity to the game. However, there are actually many complicated aspects to the game, including finding and tracking down Pokémon, battling other players' Pokémon over territory, and making strategic decisions over which Pokémon to power up based on the statistics of each creature caught. As such, it is necessary to turn to information found online in order to fully understand the game and play it to its full potential.

The study

This poster shares the results of a mixed-methods study, consisting of several parts. The first part was a survey of 161 Pokémon Go players in the state in which I performed this research. These respondents were men and women across various age groups. The survey was posted to a subreddit and two Facebook groups which were popular among players in the state. Players who were outside playing in a number of parks were recruited as well. The survey examines the motivations of players' information gathering and seeks to "map out" the resources that players use. I analyzed types of players and their various motivations for playing.

The second part of the study consists of interviews with participants who I identified in the survey. These interviews probed further the information practices of players, particularly focusing on the dynamics of play within families. Parent-child interaction was a key motivation for playing for a number of players, and I explored how families share information and mediate gameplay.

Finally, I also dive into the politics of the community around the game. Players have a somewhat contested relationship with developer Niantic, as they have shut down a number of emergent teaching sites around the game while implementing new features that may eliminate the usefulness of these fan-created sites. The teaching and learning practices of players are informed by the push and pull between players and developer.

Learning content?

It might not seem like players are learning much through their gameplay- after all, what practical good is knowledge about how to capture and battle with virtual creatures? However, this is what Gee (2007) calls "the problem of content." Although players are not learning content such as science or math while playing, Gee outlines how games engage players in deep and complex problem solving. Players must seek out information pertaining to the various problems to solve in the game, determine which information available is relevant and useful, and then apply this knowledge. This set of skills is referred to broadly as information literacy (IL). While information literacy as traditionally been framed around institutions and standards, these literacies are important in a number of informal contexts as well (Martin, 2012; Martin & Steinkuehler, 2010). I adopt Martin (2012)'s application of IL principles to her study of *World of Warcraft players.* She found that players use such literacies to seek information from other players of the game and apply it to their own gameplay, and I propose that Pokémon Go players do the same. The learning and information seeking that take place around the game are the kinds of practices learners need to navigate the vast array of information available to them today, both in informal contexts like game communities and in formal contexts such as schools and universities.

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Sequencing and Fading Worked Examples and Collaboration Scripts to Foster Mathematical Argumentation – Working Memory Capacity Matters for Fading

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Abstract: This study investigated the effects of the sequence of introducing two scaffolds (heuristic worked examples first vs. collaboration scripts first) and the fading of the primarily introduced scaffold (fading vs. no fading) on the acquisition of mathematical argumentations skills of university freshmen. Concerning dialectic mathematical argumentation skills, the scaffolds were most effective for learners with low working memory capacity when the collaboration script was primarily introduced, but then faded out.

Theoretical background

High-level mathematical argumentation requires knowledge and skills regarding social-discursive aspects of mathematical argumentation skills (MAS) in addition to domain-specific skills (e.g., Yackel & Cobb, 1998). Within social-discursive argumentation, two different types of activities can be distinguished, namely *dialogic activities* that are characterized by a joint conversation on the same arguments, and *dialectic activities* that comprise exchanging counterarguments (e.g., challenges to arguments) and the integration of different arguments to come to a joined solution (Wegerif, 2008).

Dialogic as well as dialectic activities are assumed to be beneficial for learning, but dialectic activities seem to be more beneficial than dialogic activities (e.g., Asterhan & Schwarz, 2009). Yet, learners rarely engage in such activities spontaneously (e.g., Sadler, 2004). Two promising scaffolds to foster social-discursive MAS are heuristic worked examples and collaboration scripts. *Heuristic worked examples* not only include solutions for particular problems in an exemplifying domain (e.g. elementary number theory), but also principles of a specific learning domain (e.g., how to formulate and prove a conjecture), and strategies to solve similar problems (Renkl, Hilbert, & Schworm, 2009). *Collaboration scripts* support learners with respect to specific discursive processes while being engaged in a collaborative task. Studies have shown that learning with collaboration scripts can foster the acquisition of argumentation skills because they can prompt learners to provide arguments, counterarguments and to integrate different arguments of learning partners (e.g., Kollar, Fischer, & Slotta, 2007).

A straightforward idea would be to provide learners with both kinds of scaffolds to foster social-discursive MAS. Yet, it is not clear which scaffold should be presented first because the temporal sequence by which scaffolds are presented may substantially influence learning outcomes (Renkl & Atkinson, 2007). It is also unclear what should be done with the primarily introduced scaffold when the second one comes into play. The demand on working memory should be reduced by the fading out of scaffolds which might also play an important role for their effectiveness (e.g., Collins & Brown, & Holum, 1991).

Research questions

RQ1: What is the effect of the sequence of the presentation of the scaffolds (heuristic worked examples first vs. collaboration scripts first), the fading of the primarily presented scaffold (fading vs. no fading) and their combination on learners' acquisition of dialogic MAS (RQ1a) and dialectic MAS (RQ1b) during collaborative learning with mathematical proof tasks?

RQ2: To what extent does working memory capacity moderate the effect of the sequence of presenting the scaffolds (heuristic worked examples first, vs. collaboration script first) and the fading of the primarily introduced scaffold (fading vs. no fading) on learners' acquisition of dialogic and dialectic MAS (RQ2)?

Method

One hundred and eight prospective mathematics students (M_{age} = 18.99, SD_{age} = 1.89); 45 female learners) were randomly assigned to one of four experimental conditions of a 2x2 factorial design with the independent variables *sequence of introducing two scaffolds* (heuristic worked examples first vs. collaboration scripts first) and *fading of the primarily introduced scaffold* (fading vs. no fading). *Dialogic* and *dialectic* MAS were measured at pre- and posttest. Dialogic activities included agreements or extensions of arguments, while dialectic activities comprised objections, counterarguments or integrations of arguments and counterarguments. Dialogic and dialectic activities were coded by two trained coders. (Cohen's κ for dialogic MAS: M = .71, range = .68-.75; Cohen's κ for dialectic MAS: M = .74, range: .67-.83). Working memory capacity was measured with the automated operation span task (Unsworth, Heitz, Schrock, & Engle, 2005).

Results

There was no significant main effect of the sequence of the scaffolds on (RQ1a) the dialogic MAS ($F(1,103) = 1.81$, $p = .18$, partial $\eta^2 = .02$) and (RQ1b) the dialectic MAS ($F(1, 103) = 1.92$, $p = .17$, partial $\eta^2 = .02$). Fading of the primarily introduced scaffold had a significant positive effect on the dialogic MAS (RQ1a), $F(1, 103) = 6.63$, p = .01, partial $\eta^2 = .06$, but not on the dialectic MAS (RQ1b), $F(1, 103) = 0.77$, $p = .38$, partial $\eta^2 = .01$. For learners who were at first presented with the collaboration script, the fading of the script had a significant effect on dialectic MAS dependent on working memory capacity, $b = 9.32$, 95% CI [5.29, 13.35], $p < .001$, increase in R^2 due to interaction = .23 (RQ2). Learners with low working memory capacity benefitted most from fading of the collaboration script.

Discussion

Both scaffolds may have fostered dialectic activities of MAS to a similar extent and therefore the sequence of introducing them might not have played a significant role. Because both scaffolds predominantly addressed dialectic activities, removing the primarily introduced scaffold might have reduced the amount of irrelevant information for acquiring dialogic MAS. In addition, heuristic worked examples and the collaboration script may have fostered dialogic MAS to a similar extent when they were introduced as first scaffold. Therefore, introducing the second scaffold might have been redundant with respect to dialogic MAS. When introducing heuristic worked examples and simultaneously fading the collaboration script, particularly learners with low working memory capacity may have benefitted from a reduction of the interacting elements (i.e., components of the script; e.g., Sweller, 2010) in working memory. Future studies should investigate the effectiveness of combining heuristic worked examples and collaboration scripts in other heuristic domains including learners with other levels of learning prerequisites.

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Embodied Activities as Entry Points for Science Data Literacy

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Abstract: 'InfoX' curricula focus on computer supported technology and data analysis to encourage student production of publishable science news infographics. As a primer to this, students participate in a series of embodied activities as entry points for science data literacy.

Major issues

Students of the twenty-first century are able to readily access unprecedented, and seemingly infinite amounts of data. Electronic repositories, open source information, and the ease of online search engines allow any curious person to view a vast corpus of social and scientific information almost instantaneously. This publically available data is exponentially growing and frequently available at no charge. Yet, in an age of big data and an overwhelming amount of information, young people are often inept at conceptually grasping the underlying meanings of massive numeric data sets (Hammerman, 2005). Next Generation and Twenty-First Century competencies demand that definitions of 'literacy' are expanded beyond the written text to include various forms of new media, including scientific and quantitative data sources (Livingston, Couvering, & Thoumin, 2008). This requires an education that prepares students to engage various modalities of information, different forms of representation, and interactive socio-technical systems (Yore & Hand, 2010). In response to these challenges, the "Infographic Expression'" (InfoX) project seeks to foster high school students' scientific and data literacy through the collaborative critique and construction of science based infographics. InfoX curricula are designed to engage students in scientific research, data exploration, technologically mediated communication, and ultimately the computer-supported production of knowledge artifacts by way of science news infographics.

Like many other researchers and practitioners, we observe that often students are overwhelmed by, and disinterested in, large quantitative data files. For students, and perhaps the public at large, tables, spreadsheets, formulas, and other quantitative inscriptional forms may seem cognitively inaccessible. These abstract symbols and the concepts they represent may appear disconnected from real world meaning or lived experience (Anderson, 2003). While our goal is to ultimately have students engage with a suite of online and computer supported programs that allow them to research a topic, analyze data, and communicate their findings with various representational forms; we believe that prior to introducing these technological systems, students benefit from a more grounded entry. To help ease students towards interacting with and understanding these forms of data our team has developed a series of physical activities that draw on students' real time, embodied experiences to illustrate how they may use their own bodies to represent and communicate ideas drawn from science data. Here, we showcase two data focused embodied activities that can be presented in a variety of contexts to students at the beginning of a data literacy, research methods, statistics or other STEM courses to introduce the importance of multi-modal data representations. These curricula do rely on computer supported technology and data analysis, but begin with students using their own bodies as an invitation to the discipline.

Theoretical framework

Educational scholarship has moved away from a strict cognitivist framework that holds meaning making and knowledge are processes that happen only in the head, but instead are phenomenon mediated through social interaction, practical activity, cultural norms, lived experience, and bodily engagement with the physical world (Anderson, 2003; Lakoff & Johnson, 1999). Mental representations of physical experiences are called upon as individuals attempt to understand conceptual content. As Anderson (2003) explains by example, "Chair is not a concept definable in terms of a set of objective features, but denotes a certain kind of thing for sitting"(p. 101). In this example, the concept chair is directly related to the lived experience of sitting; the idea is rooted in an embodied activity. Still, some hold that certain kinds of concepts, notably mathematics, are disembodied, totally abstract and not extended in the world (Abrahamson & Lindgren, 2014). This suggests that one cannot point to, experience, or touch complex mathematical proofs in the physical world. Yet a growing body of scholastic research on embodied cognition strongly makes the case that all knowledge, including mathematics and STEM topics more broadly, are not ground in ethereal sign systems or inscriptional forms but rather, "in the situated, spatial–dynamical, and somatic phenomenology of the person who is engaging in activity" (*ibid, p. 1).* Abrahamson and Lindgren (2014) claim conceptual understanding of *any* given content, no matter how abstract, is ground in and derives from physical engagement in the world. They explain that everyday unmediated intuitive experience must be combined with disciplinary mediated analytic reasoning to grasp complex science ideas. "In order to understand STEM content students must reconcile their unmediated perceptions and actions with the mediated structures of disciplinary practice" (p. 2-3). An essential component of STEM education and data literacy is that students can navigate between their intuitive lived experiences and a conceptual, analytic disciplinary framework. To extend the implications and practice of this conceptual approach, we are currently working to develop physical activities and protocols that draw on embodied life experiences as entry points or primers to data science and technological systems.

Methods and design

We have found that a progression of data focused initiatives involving students manipulating the physical world serves as a functional 'ice breaker' and introduction into the discipline of data science. Here, we showcase two.

Bodily Data Sorting: Physical sorting activities likely occur near the beginning of a unit. Participants may not know each other well or have had limited experience with data analysis. Participants first introduce themselves by vocally responding to series of set questions (*e.g.,* grade level, date of birth, color of their bicycle, etc.). Facilitators assign colored index cards corresponding to bins of data. For example, a student might have a green card to represent West High School and a white card to represent the color of her bicycle. Participants are then prompted to sort themselves based on a variety of conditions, using the position of their own bodies as 'data points'. One progression might ask students to first line up based on birth date (x-axis). Students might then take incremental steps forward or backwards based on their height (y-axis). Here, we note that students have created a two-dimensional graph representing birth date as a function of height and solicit any observations. The colored index cards are then introduced to provide a third and forth dimension to the human chart. Do students of certain high schools have trends related to height, bicycle color, age, etc.? This activity introduces students to ideas related to sample size, multi-dimensional data representation, correlation vs. causation, variable relationship, scale, and the effectiveness of visual representation drawing on the 'data' of their own lives.

Physical Infographics: A second embodied activity involves students creating three-dimensional physical infographics to tell a data driven science news story. Students are presented with a dense quantitative table or spreadsheet (e.g., longitudinal, demographic health trends). In small groups they are asked to examine the data, consider what kind of narrative story the information could tell, and collectively decide how they would like to physically represent this story. Students are provided with crafting materials and assorted objects and tasked to create a 3-D representation of an argument derived from their data. Through structured conversation and feedback students collaboratively discuss the process of data selection, representational forms and conventions, principles of design, and how quantitative information can support a social-scientific claim.

Significance and implications

This poster will showcase two embodied activities that are utilized as entry points into the discipline of data science and visual literacy. These physical interactions show promise at promoting conceptual reasoning. Students use the somatic experience of moving their bodies to bridge the intuitive experience toward a deeper conceptual understanding of statistics. Students create physical artifacts that serve as mediators for abstract concepts and science narratives. This work supports the notion that embodied activities may serve as entry points for conceptual, abstract, disciplined STEM practices.

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Touch | Don't Touch
Exploring the Role of Interactive Displays in Natural History Museums to Help Visitors Appreciate Objects Behind Glass

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Abstract: How can we use interactive displays in museums to help visitors appreciate authentic objects and artifacts that they can't otherwise touch or interact with? This poster shares ongoing design-based research on the use of interactive displays to help visitors learn about themes and artifacts in a cultural exhibit on Chinese history and culture.

Keywords: Interactive displays, museums, collaborative learning

A persistent question facing modern natural history museums is how to understand the role of interactive digital technology in the visitor experience. Can interactive technology be used to foster visitor curiosity and engagement around the authentic artifacts that make up museum collections? Or does it lead to a digital disconnect in which visitors focus more on screens than the objects in front of them? Can technology help enrich conversation and social interaction? Or does it lead to situations in which people are isolated from one another in galleries? Coming to grips with these questions will be critical to the continued relevance of collections-based informal science institutions.

This poster will share work from a design-based research project involving a team of university-based learning scientists and computer scientists collaborating with curators and exhibit developers from a large natural history museum. In June 2015, the museum opened a 7,500 sq/ft exhibit showcasing 350 artifacts from prehistoric times to present-day China. The exhibit is divided into five themed galleries and represents a significant addition to the museum's coverage of the world cultures. The exhibit also offers a unique opportunity for computer supported collaborative learning research as it includes over 45 interactive touchscreen displays spread throughout the exhibit (see Figure 1 for a screenshot from one of these displays). The central design tension with these displays is to harness the power and engagement of interactive digital media in a way that enhances (rather than detract from) visitor appreciation and understanding of the authentic artifacts on display.

Figure 1. An existing display sharing information about artifacts highlighting Bronze Age innovations.

Recent research suggests that digital technology can create engaging opportunities for learning in museums (e.g. Block et al., 2015; Louw & Crowley, 2013; Roberts et al., 2014). In particular, large interactive displays have become increasingly popular in museums and other public spaces. However, almost all of the extant research on interactive displays in museums has focused on the displays themselves—the display *is* the exhibit. But, this misses out on a common use case—the display is a way to help visitors appreciate the exhibit, often an authentic object or artifact that they cannot otherwise touch or interact with directly.

To help address this shortcoming, we are observing and analyzing visitor interaction and conversation at focal display cases. Our research treats the depth of visitor conversation about the objects and themes of the gallery as the primary indicator of learning (see Leinhardt, Crowley, & Knutson, 2002). To capture visitor conversations, we have set up a camera and microphone at one of the most interesting but least frequently visited display case addressing the theme of Bronze Age innovations. A sign posted near the display case informs visitors that they are being audio and video recorded for research purposes. Our discourse analysis identifies conversational features such as directing joint attention, naming or describing objects, asking questions, making inferences, and reading display labels out loud. We are also building on Loewenstein's (1994) concept of curiosity as a powerful motivator for engagement and learning. This theory suggests that by highlighting unknown but knowable ideas, we can cultivate curiosity and learner desire to seek out new information. Within this theoretical and analytic framework, we are using design-based research to explore the impact of design variations on the depth of visitor conversation.

Figure 2. Our first redesign highlights "big questions" as a way to stimulate visitor curiosity.

Our first round of designs focused on inducing curiosity by prominently highlighting *big questions* related to the themes of the display case. Figure 2 shows a screenshot from this iteration. Our analysis found that this while this redesign increased engagement along simplistic measures like holding time and capture rate, visitor conversation remained infrequent and shallow. We noticed, however, that the richest conversations tended to occur as visitors explored media content buried in sub-screens in the initial designs.

This led to our next design in which we brought this media content to the foreground and made it more interactive (Figure 3). The idea is to engage visitors with interactive content *first* and then give the opportunity to read and learn more if they are interested. This follows research on instruction design (preparation for future learning) that demonstrates the importance of letting learners explore on their own before giving them formal instruction on a topic (Schwartz et al, 2004). This poster shares findings comparing these three designs.

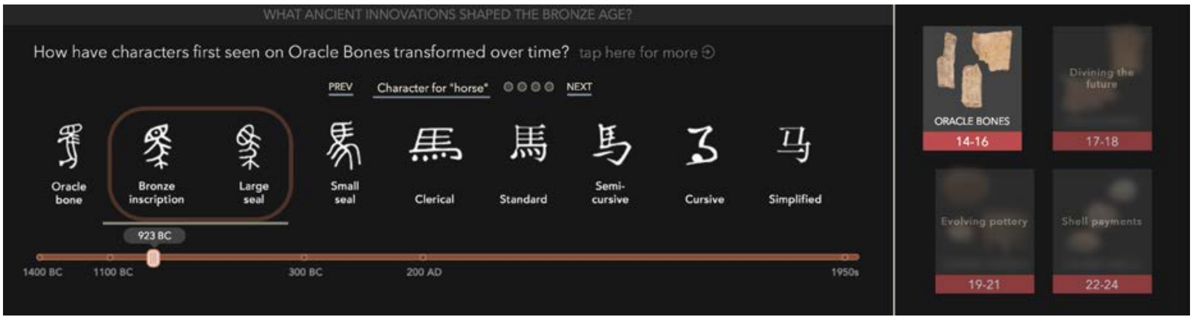

Figure 3. Our second redesign highlights interactive content first.

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The Impact of Play, Gesture, and Teacher Prompts on Student Explanations About the Particulate Nature of Matter

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Abstract: This study investigates how students use gestures to negotiate and represent their conceptual understanding. Second grade students took on the role of embodying particles within a mixed-reality computer simulation designed to display the particulate nature of matter. Students in 4 groups of 6 were quasi-randomly assigned to either a modeling play or game play condition. Results illustrate how the framing of the activity promoted gestures focused on either peers' movement, or conceptual nuances.

Introduction and theoretical framework

The present study builds upon the prior success of the Science Through Technology Enhanced Play (STEP) project, which explores the potential for elementary students to learn about the particulate nature of matter through embodied play within a mixed reality learning environment (Danish et. al, 2015). The present analysis aims to extend this in two ways: 1) by further exploring the role of gesture in supporting learning, and 2) by identifying the features of play which may have supported student learning through the contrast of two forms of play: modeling play and game play. Gestures have long been recognized as facilitators of thought and thus play a significant role in both cognition and learning (Goldin-Meadow & Beilock, 2010). Drawing on sociocultural theory, actions that involve body position and gestures are recognized as an important aspect of communication and social interaction (Goodwin, 2004). Furthermore, gestures often reveal aspects of student cognition that may not be easily identified within their talk (Crowder, 1996). Therefore the present analysis aims to examine how participants used gestures as they collectively explored the science content within the STEP environment. Furthermore, to highlight the role of the gestures, we contrast them with the verbal language used to express conceptual understanding to help illustrate the different role of gesture and language. Finally, to understand how the framing of the activity might influence the use of gestures and embodiment in learning, students were quasi-randomly assigned to one of two play conditions of the aforementioned STEP project: modeling play or game play. In the modeling play activity, students were free to create and revise models of the states of matter in whatever manner they chose. In contrast, students in the game play condition needed to represent specific states of matter in order to help a fictional robot navigate an island while avoiding hazards.

Design

The STEP environment is a mixed-reality simulation designed to scaffold students' exploration of the particulate nature of matter through embodied play (Danish et. al, 2015). Students participate by embodying the role of either water particles or energy sources and moving around the classroom. As they move, Microsoft Kinect cameras track their motion and feed it into a computer simulation, which depicts their movements as water particles in a tank. Thus, if they stand relatively still, they will see ice in the simulation, and if they run quickly about, they might see gas. Both conditions—modeling play and game play—consisted of three activities: 1) macro-level play, 2) particle play and 3) energy wand play. After each activity, students participated in a post-activity reflection discussion with their teacher to discuss their understanding of concepts being explored.

Methods

The participants were 24 second grade (7 to 8 years old) students in an elementary school in a small Midwestern city. The two partner teachers each worked with two groups of 6 students, one in the modeling play condition, one in the game play condition (conditions were randomly selected). There were three different learning activities per condition; each activity had a list of learning goals that the teachers referred to when guiding the students through the activities. All activities were videotaped for later analysis. To understand how students use gestures in each condition, we conducted interaction analysis of the video data. After an initial analysis, we then developed a coding scheme focused on the students' gestures that were concurrently used with verbal language. The coding scheme includes two non-mutually-exclusive dimensions: interaction role and conceptual content.

The interaction role dimension was further divided into two sub-codes: self-explanation and peer communication. The content dimensions were based on the prior STEP project content interview coding scheme and characterized students' reasoning as referring to matter at either a macroscopic or microscopic level, and also identified whether students associated changes in state with energy (Danish et. al, 2015).

Results

The results of interaction analysis show that each learning activity structure, and the teacher guidance to help each group navigate these activity structures, influenced the type of gestures used by students and thus the concepts they focused on. For both conditions students needed to work collectively as a group to reach the desired activity goals. Because both activity structures required different goals, each condition gave teachers a different degree of flexibility to ask prompted questions. The guiding questions and comments that each teacher used to prompt student activity within the interactive learning space shaped the ways in which the students oriented towards the computer simulation activity and the activity of their peers, and thus created opportunities for the use of certain types of gestures. In both modeling play activity and game play conditions we saw that the teachers prompted students with guiding questions and comments in order to achieve a certain goal within the computer simulation. In the modeling play condition, the more flexible activity structure allowed for teachers to ask wide-ranging questions such as "What do you notice about the dots (which represent particles)?" and "What do we need to do to make a solid?" In response to this, students' gestures were primarily oriented toward how the particles behave. On the other hand, the structure of the game play condition was based on students doing certain movements in order to win the simulated game. Teachers asked questions such as, "What happened on the screen?" or "What are you going to do?" Therefore, students used gestures to communicate with their peers that they need to change position in order to change the states of matter. However, in the discussion phase, teachers asked more about how the games related to states of matter and the behavior of particles. As a result, students used gestures to represent the speed or distance to show the differences between different states of matter.

Discussion

The majority of the gestures that were used by students in the game play condition were used in order to give directions to other peers within the group, while students in the modeling play condition used gestures to communicate a wider range of ideas. The increase in variance of gestures used in the modeling play condition in comparison to the game play condition seemed to help students more with solving problems in order to achieve goals within the activities, to communicate more efficiently with peers, and to help explain or convey understanding of certain concepts. If the structure of play activities as a competitive game versus more flexible modeling play influences the way students use gestures to understand key concepts, then this has important implications for how we design learning activities that leverage these different forms of play. Furthermore, it is important to understand the role that teachers' questions and comments play in mediating the link between activity structure and gestures so that teachers can intentionally encourage the types of gestures and discussions that will support student learning. Moving forward, we are particularly interested in the kinds of discussion that prompted sense-making and gestures that reflected the behavior of the particles and will want to support even more of this kind of interaction.

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The Effects of Explicit Collaborative Argumentation Instruction in Collaborative Argumentation-Based Learning Activities in High School Context

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Abstract: This study explored the effects of explicit instruction on collaboration in argumentation on high school students' argumentation behavior patterns. Sixty students were randomly assigned into experimental and comparison groups. In addition to argumentation instruction for both groups, explicit instruction on collaboration in argumentation was particularly received in the experimental group. This study found some similar argumentation behavior patterns between these two groups. Also, some different argumentation behavior patterns between the two groups were also revealed.

Introduction

Social Scientific Issues (SSI) has been used as authentic learning contexts where learners could acquire scientific knowledge and practice argumentation skills. Socio-scientific issues-based (SSI-based) learning is an active approach to learning. Students learn and make arguments on science content which is relevant to their own life experience (Zeidler &Nicols, 2009). However, learners may encounter difficulties when they are conducting SSIbased argumentation learning activities. It may focus on personal knowledge construction than collective knowledge building. Also, it often falls into debate-type win-lose situation easily (Andriessen, 2006; Asterhan & Schwarz, 2009). In order to solve the difficulties emerging in SSI-based argumentation learning activities, collaborative argumentation-based learning (CABL) was then proposed. CABL regards argumentation as a means to engage learners in a collective exploration of a dialogical space of solutions (Andriessen, 2006). In CABL activities, learners need to collectively contribute their perspectives and provide evidence which are used to share their mutual understanding on complex issues (e.g. SSI). It seems that CABL could improve learners' reasoning (Reznitskya, et al., 2001), build up co-elaboration of knowledge (Baker, 2009; Schwarz & Glassner, 2007), change their concepts (Asterhan & Schwarz, 2007), and solve problems (Cho & Jonassen, 2002). Nevertheless, learners may not distinguish evidence and theory or they may not accept other viewpoints in CABL activities (Jonassen & Kim, 2010). They may not form counter-arguments due to the lack of contrary viewpoints (Leitao, 2003). Thus, more teaching assistances may be needed when learners are conducting CABL activities, for example, teaching learners how to make arguments (Clark et al., 2010; Noroozi et al., 2012). The purpose of the study is to explore the effects of explicit instruction on collaboration in argumentation on high school students' argumentation behavior patterns

Methods

The participants in this study were 60 second grade high school students in northern Taiwan. The students voluntarily participated in a three-hour argumentation workshop on a weekend in the fall semester in 2015. The workshop was held in a computer lab in the high school. They were randomly arranged to the experimental group (n=30) and the comparison group (n=30). The study aimed to help students to develop higher reasoning ability to make arguments on a highly debated SSI topic, "the building of nuclear power plant", which may include different perspectives and may have more than one solution was therefore used in this study.

This study adopted a quasi-experimental design. There were three sessions: An instruction, online searching and argumentation activities. The instruction session lasted thirty minutes. The experimental group received explicit collaborative argumentation instruction whereas the comparison group received argumentation instruction without highlighting collaboration. After the instruction, all the participants searched relevant information online on a SSI topic "Can nuclear power plant solve the power shortage in Taiwan?" They needed to find relevant resources which may support their arguments. They posted their findings in the notes area in a self-developed platform where participants can conduct collaborative argumentation learning activities. The final session lasted one hour. Participants in each group were randomly arranged into a small group and did online argumentation-based learning activity.

The primary data sources were students' online entries (notes) in the self-developed argumentation platform in session 3. Students posted articles as many as possible in the third session. The students in both groups were encouraged to post articles with openers. For data analysis, all the entries were coded according to their content. The coding scheme included "My argument (A1)", "Question (A2)", "Inquiry (A3)", "Reasoning (A4)", "Supporting (A5)", "Others (A6)." The collaborative argumentation coding scheme is adopted from McAlister, Ravenscroft and Scanlon (2004). After the coding, sequential analyses were adopted to analyze participants' learning patterns. The sequential Z scores of the two groups then converted into two diagrams of sequence relationships.

Results and conclusion

As shown in Figure 1 and Figure 2, there were four sequences achieved significance in both groups: "A1→A3", "A1→A5", "A2→A1", and "A3→A1". Both group achieved significance may be due to the instruction of argumentation. It is noted that differences were found between the two groups. The experimental group achieved significance in "A1→A2" whereas the comparison group did not. The experimental group achieved significance in "A4→A2" and "A4→A5" whereas the comparison group did not achieve significance.

The results show that two groups of students tended to question arguments continuously (e.g. A1→A3), support arguments by giving positive supports (e.g. A1→A5), give further explanations when their arguments were questioned (e.g. A2→A1), give more supporting ideas when their arguments were inquired (e.g. A3→A1). It is suggested that the positions and arguments proposed in the collaborative argumentation learning activities were fully discussed. If the group members had different opinions or ideas on arguments, more explanations were given by other group members. In addition, participants in the experimental group tended to question others after the reasoning (e.g. A4→A2), give supporting opinions after reasoning (e.g. A4→A5). It seems that the participants in the experimental group preferred to respond others after digest all the information. It is found out that after receiving explicit collaborative argumentation instruction, the participants in the experimental group tend to collaboratively support and give reasons after other group members raise questions. From the results and discussion, the emphasis of explicit collaborative argumentation instruction may have positive effects on students. Students may aware that making arguments is to reach mutual understanding and to reach consensus collaboratively.

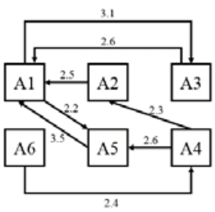

Figure 1. The diagram of sequence relationships in the experimental group

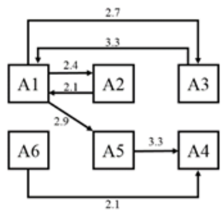

Figure 2. The diagram of sequence relationships in the comparison group

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Visualizations to Support Facilitation: The Instructors' View

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Abstract: Dashboards with visualization techniques have the potential to support instructors in facilitating multiple asynchronous small groups by tracing learning activities and making interventions with the use of synthesized real-time information. However, few studies address how instructors use these visualizations in an online problem-based learning environment. This poster presents the results of a study that examined instructors' use of a teacher dashboard in an online PBL environment using a think-aloud protocol.

Keywords: Learning analytics, visualizations, dashboard, online learning, Problem-based learning

Problem-based learning (PBL) is a student-centered instructional approach in which students learn through collaboratively solving problems in small groups, guided by a facilitator (Hmelo-Silver & Barrows, 2006). When applying PBL in an asynchronous online learning context, it is challenging for instructors to monitor and facilitate students' participation particularly with multiple small PBL groups (Schwarz & Asterhan, 2011). Learning analytics (LA) is one promising approach to helping with this challenge, but the data needs to be usable by PBL facilitators. LA refers to approaches to measure large data and present synthesized information to inform judgment (Siemens & Baker, 2012). We developed an online PBL learning system called HOWARD (Helping Others with Argumentation and Reasoning Dashboard) to support PBL and designed a built-in instructor dashboard with a range of visualization tools to support instructional decision-making (Kazemitabar et al., 2016). The data in the dashboard was condensed and processed into several visualizations, which are designed to provide synthesized information for facilitators to make informed decisions regarding how to intervene to support productive collaboration. In this study, we conjecture that instructors use the visualizations to (1) track students' participation and identify group dynamics and (2) recognize critical moments where facilitator intervention is needed.

Methods

To test the dashboard, we constructed five simulated groups' interaction in a chat component of HOWARD during a three-day online workshop. The scripts were developed in such a way that each group manifested different levels of productivity and collaboration. Two physicians and a PBL expert tested the HOWARD dashboard (see Figure 1.), during which their actions were recorded using screen-capturing software as they followed think-aloud protocol. Throughout testing, we populated the HOWARD dashboard incrementally, beginning with data for day 1. For each day, the instructors were asked to comment about the student dynamics in each group, emerging patterns and features of group interaction, and possible facilitation to support learning. In addition, an instructor questionnaire was provided in advance with a series of related questions so that instructors could reflect upon their pathways as they navigate through HOWARD. The recordings were transcribed and coded. A coding scheme was developed to examine the instructors' think-aloud process, along with an evaluation of cursor movements captured from the screen-recording data, for the purpose of identifying instructors' pathways through the HOWARD system.

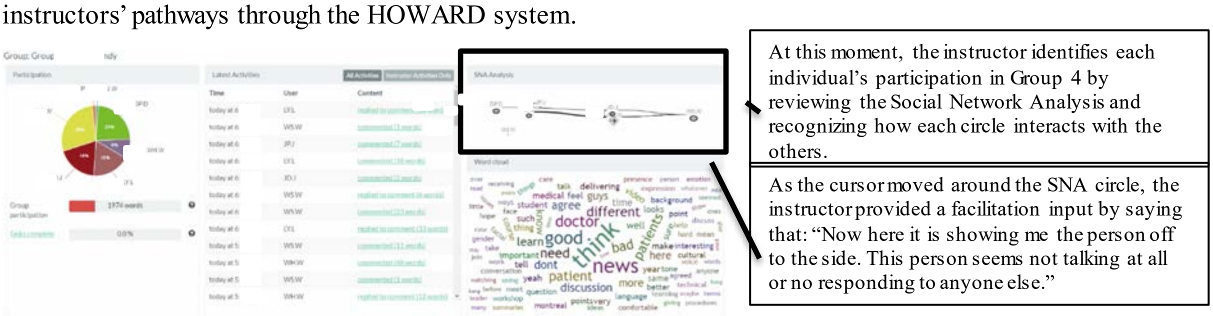

Figure 1. An example of instructor using the visualizations as inference to identify groups' dynamics.

Findings

By investigating instructors' think-aloud process and their pathways to connect the visualizations and student input, we found that instructors used the visualizations to direct subsequent actions and confirmed their judgment about group participation. Specifically, we have three major findings: (1) instructors developed an overview impression of group participation by skimming and comparing each group's visualizations and subsequently used that information to support decision-making in providing facilitation feedback. For example, after viewing the visualizations, one instructor decided to examine groups starting from a low participation group to see "what's going on". (2) While instructors viewed the input, they referenced the visualizations to confirm their evaluation about group dynamics and individual participation.

Finding (1) and (2) indicate a connection that instructors used the visualizations to get an overview of students' interactions and afterwards delved into a chat space in order to confirm or reject their assumptions. The instructors then toggled between these two platforms to find content-based evidence to support their evaluations. For example, Dr. Smith initially assumed one of the groups to be well-functioning and participating actively, saying that "looking at the social network analysis, I see a lot of multi-way conversation. I really like to look at them [students] because they are often the most fun group to look at." Then, she went into the chat space to get more information about the student's interactions. Upon further inspection, she noticed that one member, Mary, posed a question to other members in the group to ask for feedbacks, and realized that Mary was being isolated because "nobody actually answers her." To confirm her evaluation, Dr. Smith went back to the dashboard to check the SNA graph and suggested that she would have provided a facilitation input to encourage group response to Mary's question.

The third finding was that instructors frequently referenced the pie charts, SNA graphs and word cloud graphs among all the visualizations. Those tools assisted instructors in terms of understanding individual student's contributions, delineating within-group and between-group interactions and indicating keywords from group discussions. For example, Dr. Smith identified student's active involvement in regard to the discussion on leadership and distribution of roles from a word cloud graph, indicating that: "I see the word cloud shows… they [students] are talking about the roles and leaders." Dr. Wong reflected on students' participation and realized that using the pie chart might not give a direct insight into student interactions, stating that, "the amount of words being said doesn't necessarily mean that a person is contributing a lot."

Discussion and future directions

In general, though having many positive findings, we found some challenges in using HOWARD system and the visualizations that need to be addressed in order to tailor to instructors' needs and understanding. Instructors expressed a desire for the system to provide descriptions of the functions of the visualizations. Also, instructors suggested that visualizations should provide access to students' input, such as clicking a word in the word cloud to show the content related with that word. Animations or snapshots of the word cloud and SNA at different points in time could allow instructors to see the change of student interaction and group progression. For our future iteration, we plan to recruit more instructors in order to gain multiple perspectives in using the visualizations in an online PBL context. As Dr. Smith articulated that "I think that one thing that would be helpful in the long run is thinking about how do I calibrate what I see here [the visualization] versus what I see in the discussion so that I can use this to help better." As designers and researchers, we need to ensure that this calibration process is as transparent as possible.

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Bilingual Learning Spaces: Lessons From Using WhatsApp Videos in a Ghanaian Rural Context

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Abstract: This poster is a preliminary inquiry into the usage of audiovisual material for bilingual language education on the mobile application, WhatsApp, in a Ghanaian rural community. Participatory Action Research framework was used. Content creators and rural teachers observe and study the potential of Mobile Computer-Supported Collaborative Learning (mCSCL) to re-conceptualize e-learning in rural spaces with online and offline discourses in Gã and English enabled by WhatsApp.

Introduction

Research has indicated that mobile technologies help facilitate teaching and learning language, and promote general learning outside classrooms (Kukulska-Hulme, 2010; Kukulska-Hulme & Shield, 2008). An educational specialist writing for the World Bank blog on Information and Communication Technology (ICT) use in Education, Edutech, notes that mobile technologies provide appropriate solutions for integrating Information and Communication Technologies (ICTs) into education for poverty-stricken rural environments (Trucano, 2014). In Ghana, recent efforts using e-readers exist to foster technological integration into education and tackle the national literacy crisis (Worldreader, 2016). While reports indicate that 20,303 people in Ghana read on mobile phones in comparison with 16,668 people reading on their e-readers, the innovation is only available in selected local languages (Worldreader 2016). The Ghanaian language, Gã, under discussion here is not included. Using a participatory action research framework (Kemmis & McTaggart, 2000; Rearick & Feldman, 1999), the objective of this study is to explore how Mobile Computer-Supported Collaborative Learning (mCSCL) is utilized in a language education context both online and offline by rural teachers and learners.

This study is guided by two research questions: 1) What is the nature of collaborative learning within a bilingual virtual space? And 2) To what extent do rural teachers and students use mCSCL in language education, and how are identity and meaning negotiated in Gã and English within this digital learning environment? Based on the inadequate supply of pedagogical content in Gã, the investigator created and circulated short video tutorials on WhatsApp with two rural teachers who expressed interest to experiment with the media within their learning spaces. The teachers worked with 60 elementary students with a majority first language (L1) that is a designated indigenous language in the National Literacy Accelerated Program (NALAP). The NALAP is an early exit transitional bilingual education program currently in its eighth year of implementation in Ghana. It is a partnership between the Ghana Education Service and USAID, using mother tongue instruction and subsequently English to promote literacy learning from kindergarten to sixth grade levels (Leherr, 2009). Gã is one of the languages used under the NALAP system, particularly in the Greater Accra region.

Method

Presently, data for this study is being collected through autobiographical self-reflection and teacher reflection of the pedagogical outcomes by sharing and using the videos in and beyond the classroom. Some researchers affirm that autobiographical reflection is motivated by utilitarian values, affording the action researcher the opportunity to encounter "public meaning" within the experiences of their own life (Rearick & Feldman, 1999, p.335). However, standing alone, the autobiographical self-reflection is inadequate. It is better reinforced by another type of action research reflection, one that is collaborative in nature (Rearick & Feldman, 1999). Using a convenience sampling technique, additional data will be collected from WhatsApp chat forums from a sample of twenty students, the two teachers, and the researcher. Voice threads and chats that emerge from the sharing and downloading of video tutorials on the WhatsApp forums will be transcribed and analyzed using interaction and discourse analysis as described by McKay (2006). This method will aid in answering the proposed research questions. Given that this inquiry is in its initial stages, the investigator and collaborators hope that the study will evolve and become measurable by employing students' communal reflections in the future.

Conclusions

The study is still in progress. Preliminary themes and patterns emerging from both teachers' reflections are the need for the rural community to assume ownership of the project, ensure continuity and reproduction of the videos, and adopt mobile learning. The use of mCSCL in language learning has also empowered students to share in the collaborative process of learning by making content suggestions that they would like to see in upcoming videos. In addition, teachers are willing to generate their own content for these forums, thereby participating in the knowledge building process. Scardamalia and Bereiter (2006) argue that if educators are to incorporate learners into a "knowledge creating culture" thoughtfully, educational practice must be remodeled such that the worldwide web represents for students a creative space with pragmatic ways to maintain connections with the globalized world within the confines of their classroom practice (p.98). Preliminary findings from this inquiry suggest the need for more personalized solutions for integrating ICT within the educational sphere in rural Ghana. The advent of smartphones and web-based applications such as WhatsApp shows promising results for the distribution of pedagogical content, promotion of e-learning, and collaborative learning on mobile platforms both online and offline.

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Research on an International Network of STEM Media Making and Student-Led Participatory Teaching

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Abstract: This study, funded by the US National Science Foundation and the US State Department, involves computer-supported collaboration in digital maker spaces (producing videos, apps, and games to teach science, engineering, and mathematics) with students (age 10-19) and teachers. Projects entail cross-site collaboration between 16 sites in Finland, Kenya, Namibia and the USA. Research involves epistemic network analysis and development of an intercultural competency tool suitable for adolescents collaborating internationally.

Introduction

Science, Technology, Engineering, and Math (STEM) professions increasingly view intercultural collaborative competencies as critical to future workforce development. Developing such competencies may be reasonably considered as profoundly constructive aspects of STEM learning, even – or especially – in precollege years, before the selection of college majors or concentrations. The advent of international, computer supported collaboration affords the opportunity for such intercultural competencies to take form in middle and secondary school settings. The field of international collaboration between precollege students is nascent; few studies explore how fostering precollege exposure to other cultures and countries can promote STEM learning and intercultural competence. This is especially true when considering peer to peer collaborations between individuals in majority (low-income) nations and their counterparts in minority (high income) nations. This poster reports on a project that seeks to foster meaningful and scientifically meaningful international and cross-cultural collaborations between precollege students in producing STEM-related digital artifacts (e.g., digital videos, apps, computer programs, films). The intent of the artifacts is to help peers learn STEM content – that is, the artifact-makers engage in a form of what we call participatory teaching. This digital maker-space effort emphasizes help-giving, collaboration and sharing.

Methods

Participants

The study involves students between the ages of 10 and 19 years old, and teachers/professionals drawn from sixteen sites appearing in Figure 1. The individuals meet in a network of Media-Making Clubs (MMCs) with 3-15 members each. Their clubs are located in school sites in Finland, Kenya, the US and Namibia. Club activities are just commencing as of CSCL 2017. Students in the MMCs make digital artifacts including videos, short subject films, games, computer programs, and specialized applications such as interactive books that help to educate or clarify STEM phenomena to other students. For example, some students might make a short video explaining some scientific concepts related to water supplies inside the Arctic Circle or the Namib desert. Students ae expected to rely heavily on story-telling for their projects. A number of technical tools are employed to enable MMCs activities. Most major cloud platforms are used for different aspects of participant communication, especially including virtual notebooks to help students share, plan, give and receive help to other students within and between clubs. Maker tools include EdVisto, Camtasia, Construct2 to help students create digital artifacts. Clubs also have communication tools to help them communicate within and between clubs. The project takes place over 10 time zones. communication tools, both asynchronous and synchronous, include, text, audio and video communication systems.

Research questions, design and analysis

The current study relies on a number of computer supported collaborative learning (CSCL) research frameworks involving discourse analysis and emergent meaning making [e.g., 1]; intercultural competence development; the Dualism-Need-Repetition (DNR) [2] theory of mathematical cognition, and an extension of Ilgen framework for virtual group formation and operation [3]. Project research questions are organized around the themes of learning, culture, and collaboration. The primary research question asks what design principles yield the most significant promise for simultaneously improving STEM learning, and collaborative and intercultural competencies. A fuller set of questions (below) address the construct of participatory teaching, CSCL, and their interaction.

Research questions related to participatory teaching and to CSCL

- To what degree and in what ways can students take on more active and prominent roles in peer teaching
- How does participatory teaching, with its intrinsic help-giving character, alter the socio- affective development of students and the formation of learner communities?
- How can teachers adapt and excel in ecosystems in which students share teaching responsibilities?
- How do stages of group formation and operation identified by research literatures emerge when mediated entirely over virtual spaces by school-aged students and their teachers?
- How do cross-generational demographics of students and teachers affect virtual group formation?

To address these questions, several methodologies are or will be employed as the network takes form. Factor analysis cycles will be used for creating an age- and media-appropriate intercultural competence survey. Iterative design cycles will document tactical and larger paradigm shifts and adjustments. Epistemic Network Analysis (ENA), blending qualitative and quantitative tools to produce visualizations of relationships between factors in club activities [4] is a new and emerging tool. It is used in this project to visualize relationships across learning, culture and collaboration. It allows for ethnographic observation but also examination of the interconnections between culture, cognitive and socio-affective elements in what can be referred to as an individual's epistemic frame. Epistemic frames, in this theory, encompass subject-specific skills sets and competencies, but also personal world views, social competencies, cultural practices, and belief systems. ENA utilizes quantitative social network analysis techniques and discourse coding to enable aggregation and visualization of cognitive, cultural, and socio-affective interactions. ENA allows dimension-reduction and factor isolation of qualitative data in the manner of traditional principal components analysis or factor analysis cycles, but offers, additionally, the opportunity to map relationships between factors, to view those relationships, and to contrast those relationships in subsets of a population.

Figure 1. Sixteen Media-Making Club Locations

Iterations

This project design incorporates an iteration strategy with regular theory- and practice-related revisions in service of the goal is to build actionable insight into the interconnections between learning, collaboration and culture. External, independent evaluation provides the basis for annual design improvements and adjustments to serve both this international network of MMCs and help amplify the value and impact of similar future efforts.

In summary, this project focuses its investigation on informal STEM learning, collaboration and culture. *Within learning*, the project will explore participatory teaching. *Within collaboration*, the project will explore how virtual and new media collaboration arrangements differ from and can be informed by current frameworks for group function – that is, how the distributed and digital nature of the network affects overall group success. *Within culture*, it will explore development of a new inventory for assessing changes in intercultural competence, an inventory more suited to the populations of interest in this project than those served by the overabundance of current instruments. It is expected that this project will lead to theoretical and practitioner-germane insights and help spur meaningful advances to informal STEM learning and to the study of international CSCL among adolescents.

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Collaborative Sense Making in a Tablet-Mediated Informal, Place-Based Learning Environment

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Abstract: Mobile technology affords opportunities to augment a physical place with virtual layers of digital media to support place-based science learning. Our team investigated how children learned about local geoscience during a summer camp using an interactive watershed sculpture that was augmented with digital representations on iPad tablets. Findings showed the interplay among embodied experiences, mobile technology affordances, and collaborative sense making during informal, place-based learning in an Arboretum summer camp.

Keywords: mobile computing, place-based learning, informal science education, gardens

Introduction

Mobile technology affords opportunities to augment a physical place with virtual layers of digital media to support new forms of embodied and collaborative interactions (Lindgren et al., 2016). Place-based education (Semken, 2005) is an approach that localizes abstract, disciplinary concepts of global concern to transform them so that the concepts relate to people's local communities. It has shown promise for engaging culturally-diverse groups, improving factual and conceptual knowledge tied to setting, and increasing awareness of local issues (Apple, Lemus, & Semken, 2014). All place-based approaches have an intention of equitable pedagogy because they support people's sense making in ways that are personally relevant (Zimmerman & Land, 2014). Our research investigated the interplay among tangible, embodied experiences at a community arboretum that were mediated by mobile technology to support children to collaboratively make connections to their local watershed.

Methods

The participants, arboretum setting, and data sources

The study took place during a summer camp experience focused on the theme of local community across 4 days for 2 hours each day. Twenty-six children (ages 6-10) participated in the study. The episodes analyzed in this case study occurred at Arboretum at Penn State, focusing on learning about watersheds from a large-scale, interactive watershed sculpture map (approximately 10 meters by 10 meters). The sculpture map (see figure 1a) was 3-dimensional with large boulders carved to match the shape and scale of the local ridges, valleys, and mountains (figure 1b). The map was designed to model the flow of streams through the watershed when it rained or when a person poured water onto it. We designed an investigation where children explored the flow of streams in their local town tangibly, via the sculpture map, which was augmented with digital images on iPads that aligned topographical maps with surface and underground hydrogeology (i.e, sinkholes, caves, streams).

Figure 1. The carved rocks on the Watershed Sculpture Map (a, left) represent the mountain ridges visible in the distance from the sculpture map at the Arboretum at Penn State (b, right).

Data sources included video records of group interactions and children's iPad video and photo artifacts. Two focal groups were identified: Case 1 of Finn (6 years old) and Sebastian (6) and Case 2 of Rose (10) and

Sienna (9). The research team held multiple interaction analysis sessions and crafted narrative accounts of each case. Case data were compared and contrasted. The analyses presented here focus on learning about watershed and water flow, as well as the role of representations in supporting the learning of hydrogeological concepts.

Findings

Our data illuminate how tangible, embodied experiences at the watershed sculpture map intersected with digital representations of a watershed to support shared meaning-making. To illustrate, Finn and Sebastian worked together with one iPad as they began to make sense of their location by coordinating the information from the digital augments with physical aspects of their community. While Sebastian looks at the iPad, he understood that the rock that he was sitting on represented a local mountain visible from the watershed map (figure 2). He exclaimed, "I'm sitting on Tussey Mountain!" He also learned that the digital map was representing the part of the sculpture map where they were sitting, "Oh, that [digital map], is a copy of that [sculpture map boulders]. He pointed to the iPad, then to the sculpture map to share his discovery with his peer Finn.

Figure 2. Finn and Sebastian making sense of their location by coordinating digital and physical resources.

The iPad app, when combined with collaborative interactions at the sculpture map, supported scientific thinking — especially role-taking and recording of predictions and observations. For instance, Rose and Sienna shared the iPad and took turns to add water to the streams on the sculpture map, while the other recorded predictions, watched what would happen, and developed an explanation. The girls frequently used the iPad video to physically follow the flow of the stream as it moved when water was poured onto it. One child, who was recording, would use the iPad to follow the flow of the stream, while the other would narrate the video as she pointed out what was occurring on map as the water flowed downstream, representing the flow of a local creek.

Conclusions and implications

In conclusion, we found evidence that our informal learning experience that integrated place-based exhibits and digital representations led to talk and child-created video artifacts that represented community-relevant geoscience. Consistent with other studies (Lindgren et al., 2016), we observed that the children seemed to almost insert themselves into the watershed map, which helped them understand how streams in a watershed flow. This embodiment was enhanced through the affordances of the tablet device, where children physically held it above the flowing water as it moved, walking the stream (Bang, et al, 2013) to document its flow.

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The Dragon Swooping Cough: Mass Community Participation in a Virtual Epidemic Within a Tween Online World

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Abstract: While many research studies have examined participation and collaboration in virtual communities, few have designed activities and experiences that invite participation on a massive scale to support educational outcomes. In this paper we report on findings from the repeated implementation of a virtual epidemic, the *Dragon Swooping Cough*, which impacted millions and infected thousands of players in the virtual world, Whyville.net, over the course of six months in 2015-16. Our analysis of pre/post surveys and online behavior log files for survey (N = 747) and non-survey (N = 3348) participants revealed that the virtual epidemic promoted participation, primarily through engagement in protection and prevention against the virtual virus, that increased in the second outbreak. Furthermore, emotional engagement played an intriguing role in both behavioral and information-seeking behaviors. In the discussion we address what we learned about opportunities and challenges in designing activities that invite intentional massive collaboration.

Introduction

In this paper, we report on the study of a new virtual epidemic called the *Dragon Swooping Cough*, a designed virus unleashed on the virtual world of Whyville in December 2015 and April 2016. Using an innovative combination of observational methods and field experiments, research focused on understanding changes in individual online participation and engaging in prevention activities—the latter particularly important in containing an epidemic outbreak on a community scale. Here we can gain insights into designing for the particular nature of mass collaboration (Cress, Moskaliuk, & Jeong, 2016) that requires the concerted efforts of large numbers of individuals to achieve significant impact on the community level resulting, for instance, in herd immunity. Our research addressed the following two questions: (1) What factors impacted players' online participation behaviors and engagement in health prevention and protection measures? (2) Did a repeated outbreak of virtual epidemic change players' participation and use of prevention measures? To address these questions, we examined and compared behaviors, prevention and protection measures reported in surveys with those observed in log file data.

The Dragon Swooping Cough in Whyville.net

Our study took place in 2015-2016 in collaboration with Numedeon, Inc., the company that hosts Whyville and collected the tracking data and online surveys for us. Whyville.net is a massive, free virtual world (in 2016, at the time of our study, it had over 5.7 million registered players) that encourages youth ages 8-16 to play casual science games in order to earn a virtual salary (in "clams"), which they can then spend on buying and designing parts for their avatars (virtual characters), projectiles to throw at other players, and other goods such as cars and plots of land (Kafai & Fields, 2013). Building on insights gained from the earlier *WhyPox* outbreak (Kafai, Quintero & Feldon, 2010), we designed the *Dragon Swooping Cough* virus (hereafter: DSC) to reflect real-life features of infectious viruses that are particularly dangerous in the real world, like Ebola. To this end we created a virus with a long asymptomatic but infectious period (i.e., infected Whyvillians were infectious two days before they showed symptoms). Drawing on earlier findings that emotional engagement was key in triggering participation, we designed symptoms that affected the things Whyvillians cared about the most—avatars, socializing, and money— and targeted those with disruptive symptoms. Seeking to provide opportunities for action to Whyvillians, we created several preventive measures that worked to varying degrees (biohazard umbrellas, scale block lotion, masks, and hand washing), introduced tests for infection with false positives and false negatives, and provided information and graphs of current infection rates in the population.

We ran two instantiations of the DSC. The second, a mutation of the original, had similar symptoms (red scales and fire-blowing coughs) and identical infection rates. However, we made three small changes. First, about two weeks before the second virus was released, the homepage publicized that the DSC might come back. Second, a fundraising drive was begun to collect money toward research on a vaccine for the DSC. This was highly successful, raising 2,072,000 clams from 890 players in 15 days. Third, we re-organized the informational pages to be more intuitive. We hoped these changes provided better understanding and opportunities for agency.

Data collection

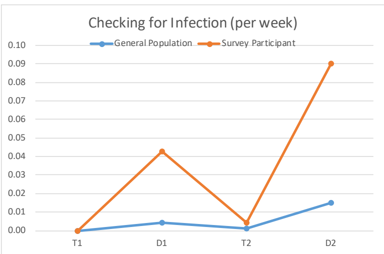
Data focused on surveys and logfiles of user activity. Surveys inquired into Whyvillians' feelings and self-reported actions about the DSC and included a post-survey after the first iteration (DSC1, N = 412), and a post-survey after the second iteration (DSC2, N = 335), with largely different participants. Logfile data included those who participated in the surveys and a subset of non-survey players randomly selected by Numedeon (N = 3348), software for inter-rater reliability amongst two independent coders on 10% of the sample (0.91 on Cohen's kappa).

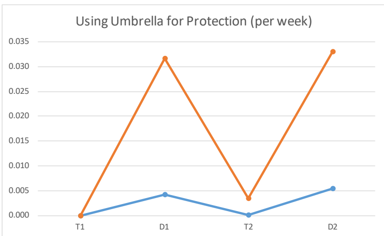
Findings

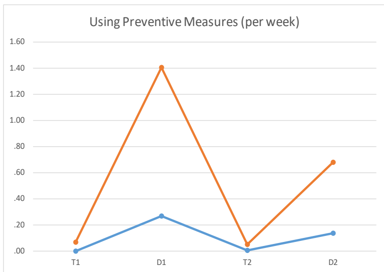
Players' reported vs. real reactions, prevention and protection responses to the DSC

The Dragon Swooping Cough elicited multiple responses among Whyvillians citizens across the two infection periods. One of the most interesting trends revealed changes in Whyvillians' activities between the two versions of the DSC (see Table 1). In particular, checking for infection, using umbrellas, and using preventive measures showed significant (but different) increases during the infection time periods, dropping to almost nothing in between infections. This demonstrates intriguing behavioral changes during the DSC. We report on other findings such as changes in emotion and the ways that emotion related to behavior in the full poster.

<u>Table 1: Charts of activity by survey participants: testing for infection, using umbrellas, and using preventive measures during the non-infection (T1 and T3) and infection (T2 and T4) periods (N = 2161).</u>







F-value (survey) = 139.455***	70.838***	76.223***
F-value (time) =154.436***	50.401 ***	78.171***
F-value (interaction) = 80.690***	27.134***	35.056***

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Bridging Students' Practical and Formal Epistemology of Science Through Epistemic Reflection Embedded in a Computer-Supported Knowledge-Building Environment

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Abstract: The goal of this study is to understand the nature of two kinds of epistemic cognition—practical and formal epistemology in situated context, and to examine how epistemic reflection embedded in a computer supported knowledge-building design can bridge them for epistemic change. Data were drawn from a larger study focusing on promoting epistemic growth among elementary students. Preliminary results showed how these two kinds of epistemic cognition were mapped in knowledge building context, with the possibility that one might have promoted the other.

Keywords: epistemic cognition; practical epistemology; knowledge building

Introduction

Epistemic cognition is an area that examines individuals' thinking about the nature of knowledge and knowing. In the recent decade, much progress has been made on the conceptualization of epistemic cognition (Chinn, Buckland, & Samarapungavan, 2011; Greene, et al., 2016; Hofer & Pintrich, 1997; Schommer, 1990), and we have also come to understand more about the situated nature of epistemic cognition (Chinn et al., 2011; William, 2012). However, there are issues relating to the nature of epistemic cognition specifically the distinction and relatedness of two kinds of epistemic cognitions that need clarification and investigation. When we explain epistemic cognition, one may say that it is about how one comes to know, how certain one is about his/her knowing, etc. However, the intriguing part is, "how certain one is about his/her own knowing" is different from "how certain one is about our human knowing". The former is about one's understanding of the nature of one's own knowledge and knowing, and the latter is about one's understanding of the nature of the general knowledge and knowing. The difference between these two kinds of epistemic cognitions was also noticed by some other researchers (e.g., Bromme, et al., 2001; Sandoval, 2005).

Along with this line, we propose that it is important to examine epistemic cognition noting the differences between these two kinds of cognition, as their distinction and relatedness may not only help us understand better about the nature of epistemic cognition, but also provide opportunity to design better intervention for fostering students' epistemic growth. In this study, we designed a knowledge-building environment enriched with epistemic reflection, focusing on linking students' practical and formal epistemology, to promote students' epistemic cognition. By *practical epistemology*, we mean individual's understanding of his or her own inquiry (Sandoval, 2005); by *formal epistemology, we mean* individual's understanding of scientists' inquiry. Knowledge building is one of the knowledge creation models in education (Paavola & Hakkarainen, 2005), postulated by Scardamalia & Bereiter (2006), with research spanning two decades, emphasizing students' collective cognitive responsibility for improving community knowledge. At the heart of knowledge building is asynchronous online discourse in Knowledge Forum® (a CSCL environment), by which the community shares and collectively develops its ideas. Underlying knowledge building is an epistemology that is similar to mature scientific inquiry, and such an authentic environment might be helpful for students to understand the nature of formal science. However, we cannot assume that students will automatically link their own inquiry experience with the mature scientific inquiry. Therefore, we embedded explicit epistemic reflection in the design to help student make the link. This study examines two research questions: (1) how were students' practical and formal epistemology related in knowledge building inquiry; (2) how did knowledge building design and epistemic reflection support the bridging of practical and formal epistemology?

Methods

This is part of a large research project focusing on promoting epistemic growth among elementary students (Lin & Chan, 2014). Two classes of fifth graders in Hong Kong (n=52) were engaged in computer-supported knowledge building inquiry with epistemic reflection. It involves students collectively pursuing ideas on Knowledge Forum, doing experiment to test their ideas, deepening their inquiry with rise-above and knowledge building talk. Throughout the process, students were scaffolded to link their own knowledge building inquiry to the scientist inquiry. Cumulatively, we used a Little Scientists model worksheet to facilitate students' epistemic reflection. The model illustrated experts' inquiry processes and epistemic norms pertaining to four different prototypes of scientists. After their teachers explained this model, students were asked to reflect on and identify those parts that they thought they had experienced when they did their own inquiry on electricity. Teachers then initiated a discussion to prompt students to investigate the similarities between their own collective inquiry process and the social construction process in the scientific community.

Data were drawn from students' individual and focus group interviews. The individual interview tapped into students' formal and practical epistemology. Eight students from each class (*n*=16) were interviewed after the knowledge-building intervention. The formal epistemology protocol asked questions, such as "how do scientists construct new knowledge", "is it a good thing scientists have different ideas". The practical epistemology questions were mapped with the formal ones but situated in their own classroom inquiry, such as "could you and your classmates construct new knowledge and how", "what do you think if you and your classmates disagree on KF discussion". In the focus group interview, four high epistemic cognition students (based on researchers' observation in classroom) from each of the knowledge building classes were recruited (n=8), and were asked whether and how they have changed their understanding of science.

Preliminary findings

Premised on theory building framework, we made preliminary analysis of students' individual interview data to examine students' practical and formal epistemology focusing on role of idea, theory revision and creation, and social progress for scientific progress (Authors, 2014). We found a general parallel between students' practical and formal epistemology among the students. In the focus group interview, many students mentioned that the Little Scientists worksheet was the most important thing influencing how they thought about science. The Little Scientist worksheet was an epistemic model that depicted the epistemic practice of several scientists, and we provided it to students to reflect and bridge their practical and formal epistemology. The interview excerpts suggested that students' experience with knowledge building made them wonder if they were doing similar things as the scientists including asking questions, giving explanations, and building theories, and that the model helped them to map their experience with what scientists do and solved their epistemic puzzlement.

Discussion

This study examines the role of a knowledge building design emphasizing explicit epistemic reflection on bridging students' formal and practical epistemology. The preliminary finding on the general correspondence between the two kinds of epistemic cognitions suggested that the intervention might have promoted their alignment, with possibility that reflection on knowledge-building experience using an epistemic model had promoted students' understanding of science. Students' focus group interview suggested the Little Scientists worksheet played an important role in influencing how they think of the nature of science. It further supports our postulation that students may not always automatically connect their science experience with the mature science, and that explicit epistemic reflection is needed to make the link. As well, such epistemic model (Little Scientists worksheet) could also be used as epistemic criteria for formative assessment of their epistemic practice. This has important implications on both ways of promoting students' formal epistemology of science and their epistemic practice.

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Individual Role-Based Profiles for Successful Team Engagement in Knowledge Building Environments

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Abstract: This study represents an attempt to uncover user profiles for productive engagement in knowledge building environments. In line with the Knowledge Building goal of re-creating schools as knowledge creating organizations, we reviewed literature on productive forms of engagement in knowledge work in out-of-school contexts and applied the TMP model to the work of students engaged in knowledge building. Preliminary results show alignment of TMP roles for team success and student contributions in knowledge building environments.

Introduction

Knowledge Building, which is described as the production and continual improvement of ideas of value to a community (Scardamalia & Bereiter, 2003), focuses on the notion of *community*; it engages students in social interactions in which students create community knowledge through engaging in Knowledge Building discourse (Scardamalia & Bereiter, 2006). Although collaborative online environments have been extensively studied as *communities* (Chen & Caropreso, 2004), there has been a growing interest to analyze individual differences in collaborative environments because community and individual achievement go hand in hand. For example, in an attempt to analyze individuals' roles in collaborative organizations, Gloor (2006) employed social network analysis on their online communication patterns and identified different roles, including innovators, creators, collaborators, communicators, learners, and lurkers. Knowledge Building, too, pays attention to both collaborative groups and the individuals (Stahl, 2002), as distributions of behaviors are valuable for achieving the goals and can predict the quality of knowledge work (Ferschke, Yang, & Rosé, 2015). This exploratory study represents a first effort to develop a role-based profile for individual contributions to knowledge building environments.

Framework

For this study, we build upon the "ways of contributing" (Chuy et al., 2011) framework. In an attempt to examine the kinds of contributions students make in knowledge building environments that move knowledge building discourse forward, Chuy and colleagues analyzed students' discourses and created a systematic inventory of ways of contributing to knowledge building discourse. This schema delineates six main categories (e.g. questioning, theorizing, obtaining information) and 24 subcategories (e.g., proposing an explanation, improving an explanation, synthesizing information). Building on the ways of contributing framework, we aim to provide a wider perspective and uncover individual differences and preferences for contributing to team knowledge work by adopting the Team Management Profile (TMP) framework (Margerison & McCann, 1995). Margerison and McCann (1995) claim that for a team to succeed, the team members should engage in a range of "types of work" (e.g. Reporter/Adviser, Creator/Inventor, Explorer/Promoter); in their model, these types of work are depicted as a wheel called *The Margerison-McCann Team Management Wheel* (Figure 1).

Reporter/Adviser gives and gathers information.
Creator/Innovator comes up with new ideas and different approaches to tasks.
Explorer/Promoter explores possibilities and looks for new opportunities.
Assessor/Developer analyzes new opportunities and makes them work in practice.
Thruster/Organizer tries to push forward and get results.
Concluder/Producer works in a systematic way to produce work outputs.
Controller/Inspector focuses on the detailed and controls aspects of work.
Upholder/Maintainer upholds standards/values and maintains team excellence.

Figure 1. The Margerison-McCann Team Management Wheel for team success (Margerison & McCann, 1995).

In practice, individuals tend to limit the type of their work to certain types of roles (Margerison & McCann, 1995). This may be true for students who collaborate in a knowledge building environment, as well. We chose TMP as the framework because it was developed to analyze individuals in workplaces, and thus would allow us to explore possibilities for an analytical framework at the intersect of 21st century education and workplaces. Integrating these two frameworks should make it possible to create student profiles within online knowledge building environments. This, in turn, could inform individuals and communities of forms of action and engagement they are currently engaged in, as well as ways to extend their repertoire and thereby enhance individual and group capacity. Such a user profile can serve as an assessment tool that could allow teachers to provide individualized support to those who need it. It can also help the researchers who employ the ways of contributing framework, to have a better understanding of each student's role in knowledge building communities.

Method and data analysis

The dataset used for this study is comprised of Grade 5 students' discourse about "astronomy" as archived in Knowledge Forum®--an online discourse medium specifically designed to support production and refinement of community knowledge. The data analyzed for this study includes 305 notes posted by 21 students over the course of 2 months. Employing the ways of contributing framework, two raters coded different types of contributions students made, and achieved an agreement rate of 97.63%. Then, the 24 ways of contribution subcategories were mapped onto the TMP roles -according to their definitions- in order to identify roles each student took. For example, as the role of Reporter/Adviser is to gather or give information, any ways of contributing subcategories that indicate giving/gathering information (e.g. explanatory questioning, introducing information) were mapped onto the Reporter/Adviser role. Also, any ways of contributions subcategories by which students proposed new ideas or different approaches to tasks (e.g. improving an explanation) were mapped onto Creator/Innovator. Some contributions fell into more than one role and were coded as demonstrating all relevant roles.

Preliminary results

For each student, different roles during the collaboration were identified. 17 students were identified as Reporter/Advisor, as their main roles were gathering information/providing information, while the main roles of four other students were proposing new ideas and different approaches (Creator/Innovator). The second role of 14 students was Creator/Innovator, while the second role of three students were identified as Concluder/Producer. Three other students had Reporter/Advisor as their secondary role. One student demonstrated a single role (Reporter/Advisor). Figure 2 shows a created student's user profile, adopted from TMP model.

Figure 2. A student's user profile.

Discussion and future directions

The results indicated that each student took several specific roles when collaborating with peers through an online knowledge building environment. However, in order to engage in knowledge creation, they need to take collective responsibility for community knowledge advancement (Scardamalia & Bereiter, 2006). Collective responsibility for idea improvement characterizes expert teams of all kinds; although each community member may have a particular area of expertise and a distinctive way of contributing to the team, they should be able to take over for one another on a moment-to-moment basis (Scardamalia, 2002). Creating such a role-based user profile would help the individuals to know more about themselves and community needs and potentials, which may encourage them to take more collective responsibility. For example, they may notice they are missing certain roles required for more effective community action. Replicating the study with a richer dataset, as well as developing a single scale that integrates the various analytic tools identified in this paper, will be the focus of our next investigation.

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Misconceptions and Their Evolution in Knowledge Building Communities

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Abstract: In this study, Grade 4 students' discourse about optics is analyzed in order to uncover students' level of consciousness of their naive conceptions, their level of commitment to their misconceptions, and their peers' collective cognitive responsibility to improve those conceptions. The results not only show that students are able to recognize a gap/conflict in their knowledge, but also provide evidence that students willingly seek information to improve their naive conceptions. The study also provides promising evidence that peers may facilitate the process of conceptual change by providing support in various ways.

Introduction

Although contemporary researchers hold a number of different views about students' naive conceptions in science—as shown, for instance, in the first five chapters of the *International Handbook of Research on Conceptual Change* (Vosniadou, 2013), there seems to be continuing agreement since the early days of research on this topic (e.g., Driver & Easley, 1978) that many common misconceptions are resistant to change and that changing them requires a skilled and knowledgeable teacher. The implication is that students are satisfied with and perhaps deeply committed to their erroneous conceptions (Mestre, 1991). A more optimistic view of prospects for conceptual change is put forth by contributors to the book, *Intentional Conceptual Change* (Sinatra & Pintrich, 2003), although this appears to be a minority view. If the more pessimistic view is correct, it poses a serious challenge to constructivist approaches that assign a high level of agency to students in their cognitive development. With Computer-Supported Collaborative Learning (CSCL) there is even the risk that misconceptions will spread. Burtis, Chan, Hewitt, Scardamalia, and Bereiter (1993) investigated this possibility with students using CSILE, a predecessor to Knowledge Forum®. Although the authors found numerous misconceptions, most of these were ignored by other students, and of those that did receive comments, more were contradicted than were endorsed. The present study is a pilot study that attempts to go more deeply into the group treatment of misconceptions in a Knowledge Building class. Applying a scheme that categorizes types of contributions to knowledge building dialogue, the study investigated the distribution of misconceptions over different types of contribution and also the types of contributions represented by responses of students to Knowledge Forum notes containing misconceptions. The overarching question guiding the research was whether students recognized problems with their naive conceptions and sought information to solve them. A cardinal principle of Knowledge Building is that students should take collective responsibility for idea improvement (Scardamalia, 2002). To the extent that they actually do this, there should be student-driven progress from naive to more sophisticated conceptions.

Method

The primary data source in this study was Grade 4 students' discourses about optics, posted in an online discourse medium called Knowledge Forum®. Knowledge Forum provides an editable set of *epistemological markers* that are called *scaffolds*. Knowledge Forum scaffolds, such as *I need to understand* and *my theory*, can be integrated into students' notes to show their "thinking` types" and encourage discourse and metadiscourse (Scardamalia & Bereiter, 2006). This study is focused on *I need to understand* and *My problem of understanding* scaffolds. In this study, first all notes that contained at least one of these two scaffolds were examined in order to identify students' misconceptions. Then, all these misconception notes, as well as peers' responses to them, were analyzed and categorized. The scheme used to categorize students' notes was the ways of contributing framework (Chuy, Resendes, & Scardamalia, 2010), which identifies six major categories of student contributions (e.g. questioning, theorizing, obtaining information) and 24 subcategories (e.g., proposing an explanation, improving an explanation, synthesizing information).

Data analysis and findings

A total of 308 students' notes were reviewed and 38 notes with *I need to understand* or *My problem of understanding* scaffolds were recognized. Among these 38 notes, 16 misconception notes were identified and categorized according to the ways of contributing scheme, taking into account the fact that some notes may fall into more than one category (Chuy et al., 2010). The analysis shows that students in this study exhibited the kinds of misconceptions commonly observed in other research. These misconceptions mainly appeared in two subcategories of ways of contributing framework: notes that expressed their personal opinions (33.33%) and notes that asked explanation questions (22.22%). However, in all the misconception notes analyzed in this study, students judged their ideas and knowledge, and were able to recognize a gap in their knowledge and theories. Therefore, they did not state their naive ideas with confidence; rather, they used *I need to understand* or *My problem of understanding* scaffolds to express their doubts or problems of understanding, and to request their friends to criticize and improve their ideas.

On the other hand, classmates' responses to misconception notes were analyzed according to the ways of contributing scheme, and categorized into six categories and 13 sub-categories. While 33.33% of students' misconception notes contained their personal opinions, only 9.76% of responses were personal opinions. Instead, the most frequent contribution types of responses were theorizing (39.02%) and working with information (26.83%) in which peers tried to improve the existing explanations (17.07%), propose new explanations (14.63%), provide evidence or reference to contradict (12.19%) or account for conflicts (9.76%). They also used analogies (9.76%) to make the situation clearer and help their peers understand the phenomena. The analysis reveals that peers mainly tried to help solve conceptual problems by elaborating new details/applying new evidence to improve explanations, or by proposing new ideas to explain phenomena. They also tried to make their friends aware of their misconceptions, using analogies or providing evidence/references to contradict a particular idea or account for conflicting explanations.

Discussion and conclusions

The study showed that students as young as age 10 have some recognition of problems with their naive conceptions and willingly seek information/criticisms to resolve those problems. When expressing their naive theories and ideas, Grade 4 students used *I need to understand* or *My problem of understanding* scaffolds to show their uncertainty about their ideas and theories. To use these scaffolds, students need to judge their knowledge and recognize a conflict or gap in their understanding. Indeed, the very use of these scaffolds suggests that students are not committed to their misconceptions; rather, they willingly encourage their peers to respond to their questions/misconceptions in order to improve their ideas. A further educationally significant finding is the willingness of students to take collective cognitive responsibility to improve the knowledge of the community and solve their peers' misconceptions. Overall, the findings of this case study support and add a social dimension to the idea of intentional conceptual change. Although these results do not show actual conceptual change taking place—movement from a naive to a more sophisticated conception—they show the antecedents of conceptual change one would expect to find in mature scientific thinkers: dissatisfaction with the current state of understanding and ability to translate this dissatisfaction into potentially solvable problems.

Future work

The preliminary results of this study provided evidence that the required steps (i.e. dissatisfaction) of conceptual change can be taken in a student driven environment. However, this study lacks the evidence to show students' ideas improved and misconceptions solved. Addressing this issue will be the focus of our next investigation.

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Networks in Small-Group Structure in Knowledge Building Discourse

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Abstract: Working in small groups is a dominant feature of collaborative learning. However, cross-group interactions are also necessary for learning. This study analyzed knowledge building discourse in which students discussed in small groups before writing on Knowledge Forum. We used the Knowledge Building Discourse Explorer (KBDex) to analyze social networks on Knowledge Forum. Findings suggested that students in small groups spontaneously formed cross-group interactions that facilitated collective cognitive responsibility. However, the emergence of concentrated leaderships in small groups was observed.

Introduction

Knowledge building is a community-oriented approach to collaborative learning (Scardamalia & Bereiter, 2014), and studies of knowledge building have, with a few exceptions, focused on the discourse of the community as a whole. Indeed, Zhang, Scardamalia, Reeve, and Messina (2009), working in a western society, found a pedagogical design in which students were not assigned to small groups, but collaborative groups were allowed to emerge to be more effective for a number of outcomes including the diffusion of new knowledge. However, smaller groups within a community remain an attractive option for teachers. To this end, we used KBDex (Oshima, Oshima, & Matsuzawa, 2012) to explore the students, words and discourse units networks in a small-group structure in knowledge building discourse.

Methods

KBDex is a social network analysis tool for knowledge building discourse, which can support metrics of the three different networks: degree centrality, betweenness centrality and closeness centrality of three types of networks: students, words, and discourse units. In this paper, we analyzed the networks of students, words, and discourse units through the metric of betweenness centrality.

Participants and pedagogical design

One class of ninth graders (n=37) from a secondary school in Hong Kong participated in the study. They wrote on Knowledge Forum 4 in the context of studying the topic of "What is good art" over a period of two months. Students were divided into eight groups of four to five students for each. Students in small groups discussed with their members first and then interacted with the whole community on Knowledge Forum.

Data analysis and findings

Data source in this study were online notes students posted on Knowledge Forum. 296 notes were analyzed using KBDex. We selected 39 words from the domain of "good art" for the analysis. The agreement between two independent words' raters was 79.3%, and their disagreements were resolved through discussion.

We selected three different times for the discourse network to monitor student's online activity, at the time of the 10 notes created, 150 notes created and 296 notes created. Figure 1 shows that students discussed different things in the beginning because there were different ideas from different groups. However, the discourse units formed into two independent clusters in the second phase and then combined all the clusters in the next development process which indicated that all the different topics from different groups were all combined together. Overall, students in small groups can spontaneously form cross-group interactions that facilitate collective cognitive responsibility.

Figure 1. Snapshots of the network of discourse through time.

In addition, we also observed the emergence of concentrated leaderships in this class (Figure 2). High betweenness centrality suggests that the student works as a key mediator in linking other nodes. We think that students 3D02, 3D03, 3D04, 3D08, 3D012, and 3D15 were potential leaders in the student network. Those potential leaders appeared in alignment to the key notes' authors who occupied 70% of the top ten discourse units with the highest betweenness centrality. Furthermore, red balls in Figure 3 show the coverage words for the potential leaders, which indicated that those leaders gained the control of the whole discourse power.

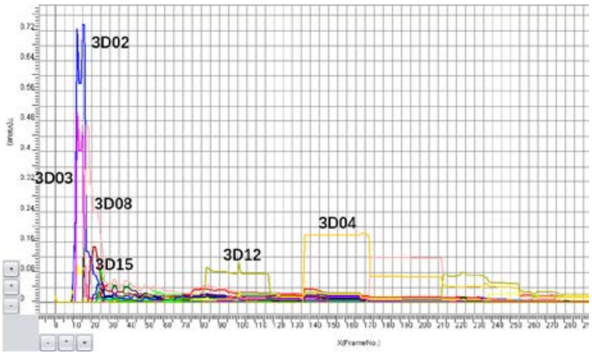

Figure 2. Betweenness centrality of student network.

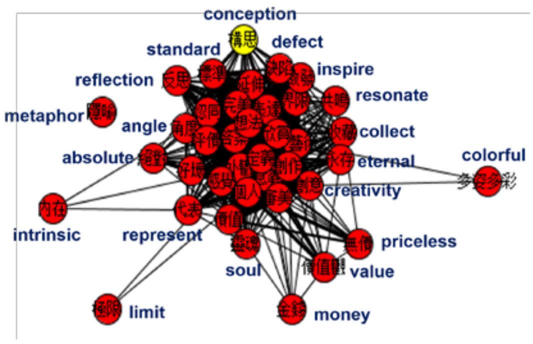

Figure 3. Words network for potential leaders.

Conclusions

By analyzing the three social networks, we can see that the small-group class can promote students' collective cognitive responsibility. However, the emergence of concentrated leaderships suggested that the whole networks were dominant to the several potential leaders. Future work should focus on design strategies for decentralizing students' leaderships to promote collaborative knowledge building discourse in small groups.

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Asking Semantically Similar Questions in Knowledge Building Communities: Patterns and Effects

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Abstract: It is not clear under what conditions do students ask repetitive questions and the possible effects of repetition on knowledge-building process. In this study, 18 groups of semantically similar questions were found in two online knowledge-building databases, and three patterns emerged: asking a similar question in advance of reading existing questions and responses; asking similar questions in parallel; asking a similar question after reading the previous question and responses. The responses to the repetitive questions tend to be more coherent in explaining.

Introduction

Questions can both open up and constrain dialogues, and can guide the direction of knowledge work (Burbules, 1993). Working on real ideas/authentic questions and problems that arise from students' attempts to understand the world is a core principle of Knowledge Building (Scardamalia, 2002). In Knowledge Building, students' ideas are put at the center, and epistemic agency is fostered so that in time students take over high level knowledge work such as, negotiating a fit between personal and others' ideas, monitoring progress, and improving the ideas as a community (Scardamalia, 2002).

A phenomenon of interest is that students may repeat questions already asked as time unfolds in Knowledge Forum®- an online asynchronous discussion environment specifically designed to support Knowledge Building (Scardamalia, 2004). In Knowledge Forum, students can enter their ideas into their community space where they can also read others' ideas and participate in "progressive discourse" (Bereiter, 1994) which emphasizes the process of improving theories and explanations rather than seeking absolute truth. Although reading the existing ideas in the community space to understand what is going on is desirable, repetition may exist and teachers may want to address the problem of repetition to help move ideas forward rather than keep repeating what has already been said (Chan & Fu, 2011). In order to better understand repetition phenomenon and to deal with it, we aim to explore: do students ask repetitive/semantically similar questions in Knowledge Building communities, and if so, under what situations do they ask similar questions? What effects may repetitive questions have on student discourse?

Methods

The dataset for this study includes 262 notes on "Rocks and Minerals" and 231 notes on "Astronomy" written separately by 20 Grade 4 students and 21 Grade 5/6 students over three months in Knowledge Forum.

We reviewed students' notes and checked whether a note contained some explicit or implicit question(s). Two researchers analyzed all the questions in each grade separately and independently in order to identify the questions that shared similar meaning. The agreement was 84.6% for Grade 4 and 80% for Grade 5, and the disagreements were resolved through discussions. We analyzed the reading history of each group of the repetitive/similar questions to determine if the author(s) who asked similar questions had read the existing questions and the subsequent responses. In addition, we checked the productiveness of the threads initiated by the questions. A thread would be considered as productive if there was any occurrence of "improving an explanation" within it (Chen et al., in press). "Improving an explanation" exhibits a movement towards greater explanatory coherence, broadening the explanation of more new facts and deepening the explanation of why theories work (Thagard, 2007).

Results

13 groups of similar questions (35% of 80 questions) were identified in Grade 4, and 5 groups (13.2 % of 76 questions) were found in Grade 5/6. Based on the reading network analysis of these questions, we found three main scenarios: (a) asking a similar question in advance of reading existing questions and responses, (b) asking similar questions in parallel, and (c) asking a similar question after reading the previous question and the related responses.

As shown in table 1, there were seven, six and five groups of similar questions in pattern a, b and c, respectively. Six threads initiated by the 36 questions (18 groups of similar questions) developed into productive threads. Interestingly, the initial questions led to one productive thread, while the repetitive questions led to five productive threads. For example, there was no response to the first question "Why does Jupiter have so many moons?" One month later, when a similar but more comprehensive question "Why does Jupiter have so many moons? And why can't we see all of them" was proposed, George replied "because some of them are smaller than others." Later he improved his theory by posting "Jupiter is far from earth we can only see it sometimes, and it's not that big when you do see it. So if it had moons even just a little smaller, we probably couldn't see it." Additionally, other students proposed that the gravity and the smaller sizes of the moons enable Jupiter to have more moons.

Table 1: The number of groups of similar questions and productive threads in each pattern

Patterns	Similar questions	Productive threads	Descriptions
a	7	3	Students who asked the repetitive questions some days later did not read the previously asked ones or the responses. Three of the productive threads were initiated by the repetitive questions.
b	6	2	Different authors or the same authors or co-authors asked two similar questions in parallel. One productive thread was initiated by the initial question, and one was initiated by the repetitive question.
c	5	1	The second inquirers or the same students read the questions posted previously and their related responses (if any), but still posted similar questions. One productive thread was initiated by the repetitive question.

Discussion and conclusion

Our findings based on a small scale study of a selected student demographic indicate the three main scenarios in which students asked repetitive questions. By checking the productiveness of the threads driven by the initial and also the repetitive questions, we found that the repetitive questions tend to lead to more productive threads. Although the teachers in Chan and Fu's (2011) study tried to avoid repetition, possibly, it is because of their assumption that repetition would not do good. Similar questions may help students summarize and synthesize the main ideas (Hew, et al., 2010).

The exploratory results imply that instead of trying to avoid repetition in Knowledge Building practice, teachers and students may try to use repetitive questions to help reflect on the diverse theories posted by students in order to achieve more coherent explanations, or to draw the community's attention to important missing ideas. Further research is needed to better understand the rationale for students asking similar questions and to verify the findings with richer data and across different contexts (e.g., levels of repetition, students' age).

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Evaluation of an Online-Environment to Prevent Frustration and Procrastination in Literature-Based Inquiry Learning

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Abstract: In the Humanities, inquiry learning usually takes place in the form of mostly self-regulated inquiry when students work with literature to write term papers. We propose a CSCL environment to support this literature-based inquiry process aiming at preventing procrastination and fostering positive emotional attitudes and high quality learning outcomes. The online-environment includes scripting and prompted learning diaries for individual use to support shared writing processes. We will present results of a control group without and an experimental group with support.

Keywords: inquiry learning, scaffolding, process support, reflection

Procrastination and frustration during inquiry learning

In higher education, students of Humanities and Social Sciences usually face inquiry learning when they work on literature-based term papers. Their inquiry learning process is quite often completely self-regulated and takes place outside of classrooms with only minimal guidance by lecturers, although we know that minimal guidance during inquiry learning is rarely effective (Kirschner, Sweller & Clark, 2006). Especially when students lack a profound understanding of the literature-based inquiry process and have only little knowledge of the learning content, the complex demands of self-regulated learning can overwhelm them and shift their focus away from relevant learning tasks.

A major problem of literature-based inquiry learning, which has been studied in the context of academic writing, is procrastination (Klingsieck & Golombek, 2016). Learners tend to delay a task until there is no more time to correctly apply previously learnt strategies or to stop and reflect about the learning process. This leads not only to problems in knowledge transfer but also to motivational issues as learners experience the academic writing process as frustrating and develop aversive attitudes towards literature-based inquiry and academic writing. Aversive attitudes towards a learning task, in turn, have been shown to be major causes of further procrastination behavior (Steel, 2007). Hence, the aim of this project is to explore how students can effectively be supported in literature-based inquiry processes to prevent frustration and procrastination and to increase quality of academic writing.

Supporting learners through scripting and learning diaries

The main challenge in literature-based inquiry is the invisibility of the inquiry process for learners and instructors as it is mainly an internal process. A supportive environment that aims at facilitating collaborative literature-based inquiry, therefore, needs to focus on 1) making the literature-based inquiry process visible, and 2) supporting the externalization of learners' internal inquiry processes.

Scaffolds that provide an externalized schema of the steps of the inquiry-learning processes and guide learners through this process have extensively been studied in science inquiry processes (e.g. de Jong, 2006) but little in literature-based inquiry processes. We can assume that a scaffold that guides learners to perform certain inquiry tasks in a given order, also if they may come back to the steps later on again, may help learners to gain a beneficial schema for future self-regulated literature-based inquiry learning processes and academic writing.

For the externalization of learners' individual learning processes and their collaborative experiences during long-term literature-based inquiry, which usually takes several weeks of self-regulated work, a learning diary seems to be a good means of support. When implemented in learning diaries, cognitive and meta-cognitive prompts for stimulating reflection about the learning process have been shown to be beneficial (Berthold, Nückles & Renkl, 2007). These suppositions lead to the following research questions:

RQ 1: To what extent does a scaffold that combines scripting and prompted learning diaries in an online-environment, foster beneficial learning processes (reflection and decreased procrastination) during long-term collaborative literature-based inquiry processes?

RQ 2: To what extent does a scaffold, that combines scripting and prompted learning diaries in an online-environment, foster learning outcomes (positive emotions towards literature-based inquiry and quality of academic writing) of long-term collaborative literature-based inquiry processes?

Methods

We designed data collection as an experimental field study on different groups of students in a B.A. program on Educational Science. The students participated in an introductory course on research practices in Educational Science during their first semester and completed the course with a literature-based term paper. The baseline group, which did not receive specific support, was surveyed in winter term 2015/2016 (N = 26) and consists of 50% students who had just completed the introductory course, the other 50% were students in a later phase of the program and had just completed a literature-based term paper in a more advanced course. Data of the experimental group, which receives support as part of the introductory course, is currently collected in winter term 2016/2017 (approx. N = 40). In the baseline group, most students had written their term paper alone, while in the experimental group, students work in dyads and submit a joint term paper. Additionally, we closely observed and interviewed three students over several weeks in a case study, while they worked on a term paper in the supportive "Online Research Log" environment.

The Online Research Log is a work-flow-management-system implemented in a moodle course and provides a structure for the different steps in the literature-based inquiry process. Each step consists of three core components: (1) Setting concrete sub-tasks for the step and dates, on which each sub-task is planned to be done, (2) conducting the step with all sub-tasks and uploading preliminary and final results, (3) reflecting about the process, focusing especially on what has been learnt, solved problems, achieved goals, and the collaboration process. The Online Research Log supports seven steps of the literature-based inquiry process: Finding a topic, identifying and understanding appropriate literature, designing an outline, writing the introduction, writing the main section, writing the conclusion, and eventually formatting the final document. Supplementary material and guidelines are available for each step. Students can, but do not have to follow the steps in the given order and are informed that it may be helpful to come back to an earlier step later on again. The Online Research Log directly supports individual learning processes, aiming at indirectly improving the dyad's collaborative learning processes and the quality of the term paper.

In both, control and experimental group, we ask the students to fill an online-questionnaire after writing their term paper. The questionnaire asks the learners about their procrastination behavior at different steps of the inquiry process and about their emotional attitudes towards future literature-based inquiry. We also ask for general procrastination behavior (trait) as a control variable. Each construct is measured on a five-point Likert-scale ranging from 1 (minimum) to 5 (maximum). Additionally, we will assess quality of academic writing and analyze process data of the experimental group collected in the Online-Research Log (e.g. reflection entries).

Preliminary findings and conclusion

The control group without support through the Online Research Log reports moderate procrastination behavior during their literature-based inquiry process. Formatting the document was related to the lowest procrastination behavior (M_{all} = 1.52; sd = 0.54), while finding a topic was associated with the highest procrastination behavior (M_{all} = 2.97; sd = 0.76); students from the introductory course showed higher values than students in more advanced courses. Emotional attitude towards future literature-based inquiry processes were rather on the aversive side for all students in the control group (M = 2.16; sd = 1.02). The students in the case study reported that the Online Research Log helped them during their literature-based inquiry process and especially reduced initial anxiety. We will present results and process data of the experimental group (with support of the Online-Research Log) at the conference, together with further findings from the control group and from the case study, and draw conclusion about the effectiveness of the online-environment.

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Multi-User Framework for Collaboration and Co-Creation in Virtual Reality

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Abstract: We present CocoVerse, a shared immersive virtual reality environment in which users interact with each other and create and manipulate virtual objects using a set of hand-based tools. Simple, intuitive interfaces make the application easy to use, and its flexible toolset facilitates constructivist and exploratory learning. The modular design of the system allows it to be easily customized for new room-scale applications.

Keywords: virtual reality, remote collaboration, collaborative learning

Introduction and motivation

While the potential of multi-user immersive virtual reality to facilitate collaborative learning is well-established, few research applications currently exist in this field. As part of our initial research, we have developed an application, called CocoVerse, that provides a broad set of creative affordances to users in a shared virtual space. Here we describe the design of this application, its utility for communication, and the educational use cases it supports. We also present useful insights on VR interface design that have arisen from preliminary user testing.

CocoVerse is intended to serve as a platform for collaborative experiences in VR. The suite of functionality within this application provides users with the capability for both primary content authorship and interaction with pre-existing environments. Starting in a shared virtual space, users can sketch volumetric surfaces in 3D with a virtual paintbrush; create and manipulate objects; capture images with a camera, and place them as pictures; and write phrases using a speech-to-text system. These affordances effectively provide a 3D whiteboard for teaching and learning. The interaction primitives we provide relate consistently to one another; for example, falling objects will rest on painted surfaces, and any user-created element can be moved or erased. This consistency ensures that users' actions produce logical results, helping to build a strong sense of presence. The sense of immersion in the virtual space is further enhanced when users are also present in a shared physical space (Beck et al., 2013).

Real-time co-creation in VR enables a broad set of educational interactions. Teachers can develop and present 3D content to students. Users can learn by interacting with dynamic systems, or by exploring and annotating environments, models and datasets. Our modular architecture can serve as a base for domain-specific experiences. Since all of these interactions are fully realized in the virtual space, they can be recorded and played back in full for immediate or later review.

Design and implementation

Our application utilizes the HTC Vive, which incorporates a head-mounted display and two handheld controllers. All three devices utilize a tracking system which maps the user's physical movements onto a room-scale virtual space with six degrees of freedom.

Virtual reality imposes particular constraints on user interface design. As discussed by Sutcliffe and Kaur (2000), users must be able to locate and recognize the conceptual objects required to carry out tasks; the objects themselves should provide cues as to their utility. We fulfill these requirements by providing users with discrete one-handed *tools*, each of which encapsulates a particular set of affordances and can be assigned to an individual controller. Tools are accessed via a virtual toolbelt positioned at the user's waist level. Once users are aware of the toolbelt's position, they are able to operate it in a hands-free fashion, thereby leveraging the spatial nature of the VR interface. This interaction model helps users to quickly explore the range of capabilities available to them, and to mix and match their active abilities, such as a brush and an eraser, to effectively carry out compound tasks.

Each tool instance is explicitly associated to the position and input of a specific handheld controller, helping users to compartmentalize their interactions. Some tools also open interfaces that are spatially bound to the opposite controller; for example, selecting a paint brush tool with the left hand produces a color palette on the right hand, which allows the user to change their paint color by dipping their brush into one of the colors on the palette.

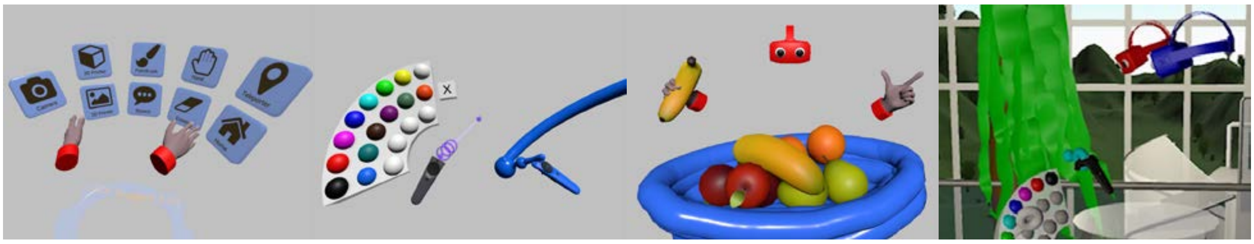

Figure 1. The toolbelt system; example of different tools; user with created objects; multiple users in environment.

Many tools can be adjusted to produce actions at different distances from the controller. For example, when using the paintbrush, users can choose to draw at one of a range of fixed distances from the controller, or to draw directly onto surfaces in their surroundings. After using the distance settings, some participants have remarked positively on them for adding accessibility to users of different physical sizes and arm lengths. Haptic feedback is provided when moving a tool's reticle across a surface, allowing users to remotely "feel" virtual objects. Users are capable of moving large distances using *teleportation*, in which the user is instantly transported to a new position in the virtual environment. Because teleportation appears as a transition between distinct still frames, the user does not experience vection and is unlikely to suffer motion sickness (McCauley and Sharkey, 1992).

Initial evaluation

We performed a series of informal trials in which the application was made available to participants at an event for VR enthusiasts. Users were introduced to the system in pairs, provided with verbal instructions, and left to explore freely for approximately ten minutes. Roughly 30 people tried the program; participants were self-selected and represented a broad range of VR experience levels. The entire three-hour session was recorded both with screen capture of the virtual environment and video recording of the physical environment.

This rapid-introduction process generated a number of insights related to our interface design. To open the toolbelt, users were instructed to position a controller inside the belt model and briefly press the trigger, as one would perform a mouse click. Many users had difficulty learning this interaction, suggesting that the controller was not seen as directly analogous to a mouse. Some users also had difficulty intersecting the controller model with buttons in the virtual environment, indicating that additional visual feedback was necessary to supplement their depth perception. Once users became accustomed to accessing the provided tools, they were able to navigate the environment and perform tasks with great fluidity. The degree of interaction between pairs of users varied; while some users performed tasks independently, others collaborated and used the tools to interact with one another.

Conclusions and future work

The CocoVerse application shows great promise as an engine for learning and creativity. At a time when VR lacks a set of canonical interface elements, such as the pinch-to-zoom functionality that is now ubiquitous in mobile applications, our tool-based interaction model and toolbelt are contributions that demonstrate robustness and extensibility. As the current feature set is polished, we intend to develop specific educational use cases, characterize the needs of collaborative teaching and learning, and offer appropriate design guidelines.

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Examining Regulation of Idea Improvement and Knowledge Advances in a Principle-based Knowledge Building Environment

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Abstract: This study examined students' knowledge building and regulation strategies in a computer-supported knowledge building environment, and specifically examined students' self-regulation and co-regulation strategies through students' discourse and reflections in Knowledge Forum®(KF). Participants were one class of grade-nine secondary school students. Qualitative analyses of both students' discourse and portfolio notes in KF identified three patterns of regulation including self-regulation, co-regulation and collective regulation for idea improvement. Quantitative analysis indicated that students' metacognitive and regulation engagement was correlated with their domain understanding.

Introduction

Scaffolding students' use of regulation strategies has always been the focus of research on learning, specifically in the computer-supported collaborative learning environment (CSCL). With increasing studies have been conducted to investigate students' regulated activities in CSCL with use of technology in class teaching (Järvelä & Hadwin, 2013), however, much research on regulation of learning focused on task-based activities and emphasized on the completion of task, few studies have examined students' regulation of idea improvement and knowledge advances in a principle-based knowledge building environment, which is an idea-centered context and emphasize on principles rather than procedure (Scardamalia & Bereiter, 2006). Generally, the purpose of this study was to examine how a designed knowledge building environment can scaffold students' regulation strategies of idea improvement and knowledge advancement at both the individual and community levels. Specifically, three research questions were addressed (1) What was students' KB participation and engagement in metacognitive and regulative process in KF, and what was the relationship between students' regulative processes and their domain understanding? (2) What characterized students' self-, co-, and collective regulation in both collaborative inquiry and individual portfolio notes, and how are they related to students' collective knowledge advancement? And (3) What were the relationship among students' KF participation, regulation strategies, and domain understanding?

Methods and design

Participants and design of a knowledge-building environment

Participants were forty Grade 9 students who studied and involved in a KB environment in a secondary school in Hong Kong. In this study, knowledge building pedagogy was implemented with four interwined components including: (1) Constructing a collaborative classroom culture; (2) Starting progressive inquiry in Knowledge Forum; (3) Deepening knowledge building discourse; (4) Portfolio assessment for regulate knowledge building.

Data sources

Data included (a) students' domain understanding on the topic; (b) KF participation which was examined by the Analytic Toolkit (ATK) provides the quantitative indices; and (c) portfolio notes and collaborative discourse for analysis of regulation strategies for idea improvement at both individual and collective levels.

Analysis and findings

Q1. Examining relations between KF regulated indices and domain understanding

Paired sample t-test indicated that there were significant differences from period 1 to period 2 on the number of scaffolds, $t(39)=3.805, p<.001$; number of references notes, $t(39)=3.558, p<.01$; and number of notes revision, $t(39)=2.054$, $p<.05$. Correlation analysis indicated that the three regulated indices were correlated with their domain understanding (.391, $p<.05$; .580, $p<.01$; .349, $p<.05$), respectively. These results suggested that students were increasingly engaged in meta-cognitive and regulation processes over time, as well, students who were more engaged in metacognitive and regulation processes also scored higher in their domain understanding.

Q2. Characterizing and examining regulation strategies and knowledge advance

Regulation strategies in KB collective inquiry and characterization of regulatory strategies

The second question examined the characterization of students' regulation of idea improvement in knowledge building discourse and relation with knowledge advance. To examine how students regulated their discourse for productive inquiry, we first examined KF discourse in terms of inquiry threads that address a principle problem. We coded the threads in line with KB theory focusing on knowledge advancement shown in the threads. We identified three discourse patterns: low level knowledge advance (LKA), moderate-level knowledge advance (MKA), and high level knowledge advance (HKA). A second rater coded 30% of the threads. Cohen's Kappa was K=.822, P<.001, indicating a good inter-rater agreement.

Within each inquiry thread, the computer notes were examined for evidence of regulatory strategies. Three patterns emerges adapted from the general idea of Järvelä and Hadwin (2013). Self-regulation refers to students reflecting on their own ideas ("*Earlier I thought that…after reading it, now I thought that…*"); co-regulation involves students working with others to monitor their understanding ("*I didn't agree with your ideas… The evidence you found are not related to our topic...*"); and collective regulation means students' examining, monitoring and regulating community's collective understanding (*We had a discussion on the reasons* for…[1]*Liu Bei's ability*[2]*determination the host*[3]*moving*···*Now I summarized what we discussed…*).

Regulation strategies and collective knowledge advance in discourse threads and portfolio

Using the coding scheme above, we coded students' KB discourse and portfolio, a reflective assessment where they tracked their knowledge advance (Chan & van Aalst, 2004). Table 1 showed the means and standard deviation of self-, co- and collective regulation LKA, MKA, and HKA in KB discourse and portfolios.

Table 1: Means and SD of self-, co-, and collective regulation in LKA, MKA, and HKA

Knowledge Building Discourse				Portfolio Notes			
Threads	SR	Co-R	Coll-R	Portfolio	SR	Co-R	Coll-R
LKA (7)	3.71(1.38)	4.86(2.27)	.43(1.13)	LKA (8)	0.38(0.74)	0.88(1.13)	0.75(1.16)
MKA (9)	5.00(2.29)	5.44(2.19)	1.89(1.36)	MKA (18)	1.29(0.89)	1.39(1.09)	1.78(1.90)
HKA (7)	10.71(4.5)	13.6(5.19)	4.00(1.91)	HKA (14)	4.07(2.13)	4.00(3..62)	2.93(4.21)

Q3. Relations among participation, regulation, and knowledge advance

Correlation analyses were conducted to investigate the relationship among KF participation, regulation of learning (high level), and domain understanding. Findings indicated that students' domain understanding was significantly correlated with self- (r=.440, p<.01), co- (r=620, p<.01), and collective regulation (r=.324, p<.05). Furthermore, regression analysis suggested that over and above prior knowledge, KF participation (R^2=.145) and regulation strategies (R^2=.127) contributed to the domain understanding.

Conclusion

This study examined a KB environment where students can post questions, ask for clarification, construct explanation, and monitor own, group and community progress. With distributed expertise, students can discuss and compare different views and theories, and employ strategies examining own and others' understanding while working on problems. The findings align with current research on regulated learning and we extended that to regulation of idea improvement. Our qualitative analysis illuminated regulation using a knowledge-building perspective. And quantitative analysis showed that regulation was correlated with KF participation and domain understanding. Further analysis would be conducted in investigating students' understanding and experience on the intertwined relationships between principles and strategies for promoting knowledge advance.

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Epistemic Understanding of Discourse and Collective Responsibility in a Knowledge Building Community

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Abstract: This study examined students' discourse and collective responsibility in a computer-supported knowledge building environment supported by Knowledge Forum® (KF), and specifically focused on investigating how students' KF participation and knowledge-building involvement relate to their understanding of inquiry and discourse. Participants were one class of a secondary school students. Knowledge Building Discourse Explorer (KBDeX), an assessment tool in exploring the network structures of students' discourse, was used to examine students' collective responsibility and identify the pivotal points in their KF discussion. Findings indicated that students who took the collective responsibility and played as an essential role in the pivotal conversation turn had a deeper understanding of discourse than students who did not involve in the community discussion. Implications of using KBDeX and investigating of students' understanding of discourse were discussed.

Introduction

This study report a preliminary findings in examining how students engage in the knowledge-building discourse, mediated by Knowledge Forum® (KF), an online discussion platform, and to investigate how their online discourse and collective responsibility were related to their epistemic understanding of discourse. Considerable research had examined how to improve students' sustained discourse in a KB environment, which emphasize on idea improvement and collective responsibility in adding value to the community knowledge advancement (Scardamalia & Bereiter, 2006), through various reflective assessment, such as the electronic portfolio (Chan & van Aalst, 2004), the Knowledge Connection Analyzer (Yang, van Aalst, & Chan, 2016). However, few studies examined students' epistemic understanding of inquiry and discourse and its relations to students' KF engagement. In this study, we used students' KF discourse as the input data to identify students' collective responsibility and the pivotal points in their conversation turn through KBDeX and investigated students' understanding of discourse through interview, as well, using the results from KBDeX to guide further in-depth discourse analysis. Specifically, we addressed two research questions: (1) What and how did students take collective responsibility in KF discussion at the group and individual level? (2) How did students' epistemic understanding of knowledge building inquiry and discourse related to their KB involvement.

Methods

Pedagogical design and data sources

One class of students from a secondary school in Hong Kong participated. There were 18 students in this Grade 11 class who took visual arts course in a KB environment. The aim of the designed learning environment was to scaffold students involve in a collaborative learning environment. The designs were (1) Developing a collaborative culture; (2) Scaffolding KB inquiry in KF; (3) Deepening KB through KF discussion and classroom practices; (4) Writing individual reflection. In this study, the data included (a) KF discourse for social network analysis using KBDeX (Oshima, Oshima, & Matsuzawa, 2012); and (b) Interview data for students' understanding of inquiry and discourse.

Results and discussion

RQ1: Students' collective responsibility in KF discussion at group and individual level

Figure 1 showed students' betweenness centrality. Each colored line represented a student. The X axis represents students' conversation turn in KF while Y axis represents the value of betweenness centrality. In Figure 1, several colored lines had the higher value of betweenness centrality. For example, student 30 (blue line) peaked at turn 20 with value of 0.19 and took the leading role over the discussion. Further, we aimed to explore on student 30 at an individual level.

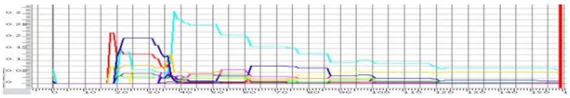

Figure 1. Student' betweenness centrality.

Figure 2 showed the network structures changing over time and the pivotal conversation turn that the leader (student 30) played in the discourse and words network. In Figure 2(a), both the network of discourse and words at turn 19 was segmented, which indicated that students did not engage in a cohesive discussion. In Figure 2(b), the note 3329 (highlighted with red) linked the two clusters of notes, and the word "cognition" and "different" connected the two clusters of keywords, which indicated that students started to engage in a cohesive discussion at turn 20. It suggested that the turn 20 (student 30) was a pivotal turn which caused network structure change.

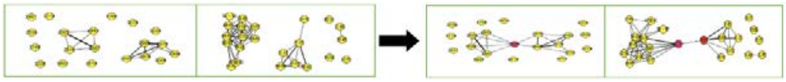

Figure 2. Network structure of discourse and words at turn 19 and 20.

RQ2: Students' understanding of discourse and relations to KB involvement

To investigate students' understanding of KB discourse and their involvement in KF discussion, we conducted individual interview for leader and non-leader based on the KBDeX results. Table 1 showed that the examples of the leader and not leader answers on "*What do you think is a good question and discourse?*" In this example, student 30 and 36 mentioned that diverse ideas and integration on community's discussion are important; meanwhile, they also emphasized the importance of reference and authentic problems. These points were all the key principles for KB community. However, student 31 and 58 did not mentioned these points. Results indicated that students who had a deeper understanding of inquiry and discourse take more collective responsibility and KB involvement than students who had a superficial understanding.

Table 1: Interview data on understanding of inquiry and discourse

Student 30 (Leader)	"A good question should relate to our topic, and it provides examples to illustrate. A good discourse should have diverse ideas…When people have different ideas, a new question will be emerged. A good discourse should include integration discussion…and reference on others' ideas."
Student 36 (Leader)	"A good question can help people think more deeply and have ideas from different perspectives; the question should be the authentic problem…a good discourse should be continued discussion asking further questions to make discussion into a higher level."
Student 31 (not leader)	"I think a good question should have content and ask the important points, not the superficial things…A good discourse should have a centered problem…and then get a conclusion in the end. "
Student 58 (not leader)	"A good question should broaden my thinking; and a good discourse does not have specific criteria…maybe should also help me thinking with examples."

Conclusions

This study reported preliminary findings on student who had a deeper understanding of discourse would take the collective responsibility and played as the essential role in KF discourse network changing. KBDeX using provided a way to identify pivotal points in students' conversation turns, which will scaffold further in-depth discourse analysis. Further investigations will be conducted to do qualitative analysis of students' discourse based on the pivotal points detecting by KBDeX and detailed quantitative analysis in investigating the relations.

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Interactive Events

Braincandy: A Cloud-Based Platform Providing Students Authentic, Engaging, and Safe Spaces to Articulate and Refine Oral Argumentation

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Abstract: New standards call on educators to facilitate oral argumentation in the classroom, but many educators do not know how to create learning environments that support equitable and accessible spaces to share half-formed ideas and argue about their merits. In this deep dive interactive session tutorial, participants learned to use Braincandy, a cloud-based pedagogically-driven application, to provide authentic, engaging, and safe spaces for their students to refine their arguments. This hands-on two-hour interactive session featured opportunities for participants to develop class material for themselves and a chance to practice using Braincandy to facilitate oral argumentation. Finally, on the basis of these experiences, participants played a role designing the next iteration of Braincandy by discussing the needs of the community regarding argumentation in the classroom and how to address them with tool like Braincandy.

Theoretical background and relevance to field and conference

Oral argumentation

For students to think deeply and critically in the classroom, instructors need to support critical talk in the classroom and elicit students' prior thinking as welcome part of constructing deeper and more formal understandings (Henderson, MacPherson, Osborne, & Wild, 2015). A new generation of science standards place critical speaking and listening, particularly with respect to evidence-based argumentation, as a key practice in the learning of science. Science argumentation is a dynamic, rapidly-growing research strand that has significant influence in the United States education standards for literacy (Common Core State Standards Initiative, 2010a), math (Common Core State Standards Initiative, 2010b), and science (NGSS Lead States, 2013). Argumentation, and using evidence to support claims, is also a major focus in the European Union (2006) and PISA (OECD, 2006; 2013), respectively.

In science education, the emphasis on argumentation in current policy documents is supported by research that establishes constructing, critiquing, and refining evidence-based arguments not only as a central practice of scientists (Latour, 1999; Latour & Woolgar, 1986), but also of learning science (Osborne, 2010). Additionally, oral argumentation, which includes the practice of defending and refining evidence-based arguments through peer debate, constitutes *interactive* learning – a mode of cognitive engagement that has shown through myriad studies to be associated with the deepest form of learning (Chi & Wylie, 2014). Braincandy is a technology designed to facilitate oral argumentation among students and collaboration among teachers who want to introduce effective argumentation in their classrooms.

Why this matters to the CSCL community?

Braincandy poses questions that students answer under the veil of anonymity, which provides a safe space for students to volunteer prior thinking they would normally be reticent to share out loud. In this case, a safe space, is a space where students can show their progress and prior thinking without fear of judgment from peers or the instructor. When students begin a lesson they often hold differing schemas. Anonymity allows students to make more authentic contributions revealing that students commonly share diverse viewpoints. The Braincandy system utilizes visualization tools allow students to see this uncertainty as a group. Classroom uncertainty sets the stage for students to argue critically and collaboratively with the goal of reaching consensus. Braincandy creates authentic opportunities for collaborative classroom talk by making prior thinking not a hindrance, but rather, an integral part of constructing more nuanced thinking. This being said, using Braincandy to facilitate peer-to-peer argumentation is not as easy as simply adding the technology to the classroom. There are best practices with regard to the design of Braincandy questions and the use of anonymous student responses to those questions. Hence, the focus of this interactive session was on BOTH technology AND pedagogy.

What is Braincandy?

Braincandy is a technology allowing teachers to engage students in research-based practices supporting deeper learning. Students are provided multiple tools for sharing their thinking, and as all contributions are anonymous, sharing is more frequent and more authentic. Iteratively developed by a collaboration of teachers and researchers, Braincandy gives students a voice in the classroom. Braincandy motivates students to articulate their emerging ideas by providing a platform for teachers to present thought-provoking questions and elicit student feedback in multiple ways. Specifically, Braincandy has three major functions:

1. Similar to a clicker or polling system, students can answer questions provided by the instructor with any web-enabled device (See Figure 1). Beyond a clicker or polling system, students can indicate confusion, answer open-ended questions, and provide anonymous feedback directly to the instructor.
2. Instructors can read results, confusion level, and written feedback on a live dashboard and present the results (bar graphs or word clouds) to students (See Figure 2).
3. Questions, and the student responses to these questions, are saved anonymously in a public repository allowing for instructors to borrow the material of others. Additionally, Braincandy provides channels for peer review among instructors.

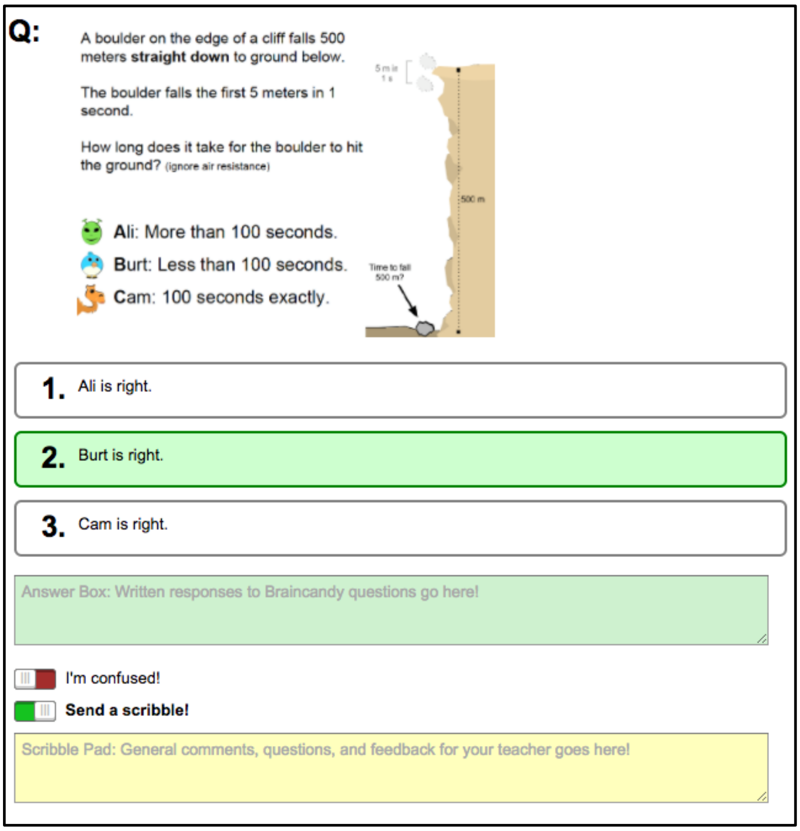

Figure 1. The Braincandy student interface. For multiple-choice questions, students simply click on one of the answer boxes, and are free to change their vote as often as they wish (the answer highlighted in green indicates the current response being sent to the instructor). The green Answer Box allows students to submit written responses to open-ended questions. Scribble Pad allows students to scribble down a message to the instructor at any time, and students are also able to notify the instructor whenever they might be confused (a notification sound is played for the instructor, as well as a count of how many students report being confused). In all cases, the feedback students provide their instructor is completely anonymous, thereby providing a safe space for students to articulate their current thinking, regardless of what stage that thinking might be at and/or how confident the student might feel in their current thinking.

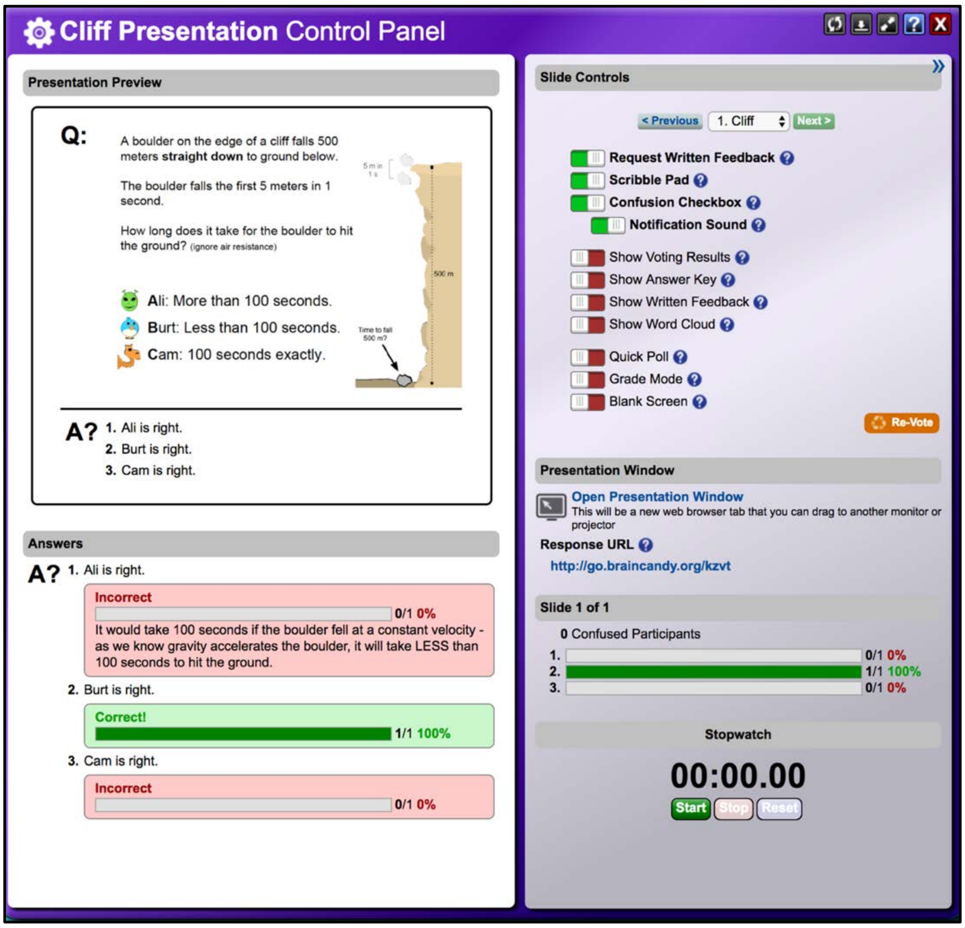

Figure 2. The Braincandy teacher dashboard. Preview of the current class question is in the upper left. Annotations for correct and incorrect answers are found on the bottom left. The upper right shows the different tools a teacher can toggle on or off to solicit various forms of feedback from students. Real-time tabulations of student responses are displayed on the bottom right. Also on the bottom right, a click on Open Presentation Window allows student feedback to be projected to the front of the classroom. Meanwhile, the Response URL is where students are directed to submit their responses – free of charge and with no login account necessary.

Interactive session description

Audience

This tutorial was designed for two types of participants: (a) participants interested in using the Braincandy platform in their own classroom to elicit feedback and support peer instruction and oral argumentation and participants interested in the use of design-based research to iteratively refine pedagogically-driven applications for the classroom.

Session goals

In this interactive tutorial, our goal was to create a collaborative hands-on learning experience. We taught participants not only how to use the Braincandy platform to create and present questions, but how to use Braincandy effectively in the classroom to facilitate active student discussion and open dialogue between instructors and students. The tutorial was technologically and pedagogically focused. Participants were expected to create their own questions, their own presentations, and discuss their own ideas about how to use the tool to facilitate collaborative discussion in the classroom. Additionally, participants brainstormed with the developers to co-create a new iteration of Braincandy.

Table 1: Timeline

Activity	Minutes	Description
Introductions	20	Using Braincandy to elicit information, participants joined a Braincandy session on their computers, tablets, or phones to answer a few introductory questions about their content interests and their reasons for joining the session.
How to Create Questions	15	Showed short animated video and presented lecture introducing Braincandy and explaining how to create questions using the platform.
Hands-On	45	Working in pairs, participants created questions and presentations based on their content interests. The two organizers walked around the room providing personalized feedback.
Using Braincandy in the Classroom	15	Demonstrated how to use Braincandy in the classroom. Including how to introduce Braincandy to a new class, how to respond to feedback constructively, and how to use responses to encourage productive and safe classroom oral argumentation among peers.
Debrief/Co-design a new iteration	15	The group discussed findings and experiences. Together the group brainstormed ideas for ways to improve the next iteration of Braincandy and ways to use Braincandy in the classroom (through a Braincandy question, of course).
Questions	10	A final ten minute session to ask questions.
Follow-Up	Post-Tutorial	Sent survey to participants asking for feedback. Provided contact information to participants in case they have further questions or need technical support for Braincandy.
Total	**120**	

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Investigating Computer Supported Collaborative Learning in Collegiate E-sports

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Abstract: Collegiate e-sports have grown in popularity in recent years, but research is lacking on the learning practices and processes happening during these collegiate competitions. By presenting video data on micro-level shifts in learning and mastery processes during a collegiate competition, we facilitate a discussion on how collegiate players demonstrate key aspects of collaborative learning during high stakes matches.

Keywords: collegiate e-sports, computing competitions, collaborative learning

Introduction

Electronic sports (E-sports) has grown in popularity in the past decade, particularly with the rise of gaming as a spectator sport (Takahashi, 2016; Wingfield, 2014a). The increasing visibility of gaming in and through venues such as Twitch.tv, and even ESPN, has propelled e-sports into the mainstream. Figures estimate that Twitch alone has over 100 million viewers a month - higher than some television viewership - with over 21% of viewership dedicated to e-sports competitive play, mostly focused on League of Legends and DOTA, two popular Multiplayer Battle Arena Games (Takahashi, 2016).

However, as an informal practice, little is known about learning and mastery in competitive e-sports game play. For example, most of the research on learning with digital games focuses on situated learning in multiplayer role playing games (e.g., Steinkuehler, 2007) or systems thinking, historical role play and reflection with turn-based strategy games, such as *Civilization* (e.g., Steinkuehler & Squire, 2014), which are often lower stakes activities when compared to the level of competitive mastery and collaboration needed in e-sports play. Furthermore, as universities start to invest in e-sports as collegiate sports (Wingfield, 2014b; Tracy, 2017), there is more that needs to be understood about the connections between other aspects of players' collegiate experience. For example, while this university setting under investigation does not have an institution-sponsored e-sports team, students are forging their own alliances with professional collegiate sports leagues, organizing national tournaments, and connecting learning in their journalism classes to e-sports broadcasting. Another area particularly important for investigation in the learning sciences is how players interdependent on one another on a team are engaged in social dimensions of collaborative learning, and how they engage in an array of reflective techniques that can both support individual situated cognition and distributed cognition amongst others.

Another important area of consideration, which aligns with this year's theme, surrounds equity and access to and within gaming and e-sports. For example, many researchers have investigated inequity in gaming, particularly for women and ethnic minorities. Research shows that competitive gaming environments are particularly exclusionary for these groups (Richard & Hoadley, 2015) and can even evidence stereotype threat (e.g., Richard, 2016; Richard & Hoadley, 2015). Further, there are many similarities between the lack of diverse participation in collegiate e-sports, hackathons and other computing competitions (Kafai, et. al., 2014; Richard, et. al., 2015), let alone the longstanding equity issues around national collegiate athletics (e.g., Hattery, Smith & Staurowsky, 2007). Thus, it is not only the potential for collaborative learning that needs to be explored, but also the potential barriers to participation. In other words, psychological safety (e.g., Edmondson, 1999) in these learning contexts is important.

Specifically, here, we explore the ways that a national collegiate e-sports tournament, organized by a student organization, is demonstrative of the kinds of learning involved in professional digital game play. We explore a detailed case study of one team's progression throughout the tournament as evidence of micro-level shifts in mastery and expertise through simultaneously collaborative and competitive game play. This particular team was chosen because the players had not practiced as a team before the tournament, but were familiar with each other through the club, and through informal play.

Learning with E-sports

Jean Lave and Etienne Wenger (1991) originally coined the term "communities of practice" (CoP) to refer to the "legitimate peripheral participation" that occurs in hobby and practitioner communities. Increasingly, CoP literature has been used to document game-based learning through communities. Matches represent a moment in time when mastery and effortful practice can be tested and thus an interesting learning case study to explore. In e-sports, particularly, Multiplayer Online Battle Arenas (MOBAs), like League of Legends ("League"), drafting is a crucial part of the game, similar to traditional athletics, such as football and basketball. There are over a hundred different "Champions" (characters) and each one of them brings something different to the game. Before the match begins, teammates collaboratively decide what their best strategy going forward is. This usually includes (a) choosing Champions each individual can play effectively, (b) negotiating which Champions work together based on individual skill and team balancing needs, and (c) banning other Champions, which would strengthen the opposing team. Kim and colleagues (2016) describe this as the proficiency-congruency dilemma, which was developed from research on organizations, sports teams, and video games.

The proficiency-congruency dilemma (Kim, et. al., 2016) extends upon deliberate practice (e.g., Ericsson, Krampe & Tesch-Roemer, 1993), which describes how people become experts in their given fields through extensive and effortful rehearsal. In other words, more experienced players have gained an understanding the intricacies involved in play, such as choosing characters based on anticipated or actual complexities that can occur. Research shows that teams that are better able to capitalize on team proficiency (expertise of a variety of characters roles needed on the team) instead of individual proficiency (individual expertise with certain characters) perform better, as do teams that have good congruency, or group cohesion. Congruency is achieved through matching the best roles needed on the team and with the characters available for the team. Unsurprisingly, more expert players are better able to have both high team proficiency and congruency because they have developed "superior mental models of how in-game roles complement each other [which] novices have to develop…over time" (Kim, et. al., 2016, pp. 4359). However, unfamiliar teams and blended teams with expert and novice players can partially bridge the gap through discussion.

Integration with CSCL

While there has been growing research on the ways that mastery can be demonstrated through e-sports competitive play (e.g., Kim, et. al, 2016), we contend that mutually shared cognition and group cohesion (e.g., Miyake & Kirschner, 2014), team interpersonal beliefs (e.g., Edmondson, 1999; Kreijns, Kirschner & Jochems, 2002), interdependence (e.g., Van der Vegt, Emans & Van der Vliert, 1998), and reflective processes (e.g., Collins & Brown, 1988) – constructs important to CSCL - are also evident. We see competitive play not only as a means to demonstrate mastery but also as a process to enable and explore micro-level shifts in group and individual learning, which can be investigated from match to match in one tournament.

Aims of the session

This session aims to introduce CSCL scholars to League and e-sports practices by examining video data of a team of collegiate tournament players who could be considered blended in expertise. We will start by describing League in detail and discuss some of its key characters and game mechanics, as well as the lingo often used around game play. We will then show short excerpts with transcripts so that participants can engage in and discuss the kinds of collaborative and individual learning processes they observe. Finally, we will provide some initial findings we have found to engage participants in a discussion around the video data, more specifically, and the relevance of e-sports to CSCL research, more generally.

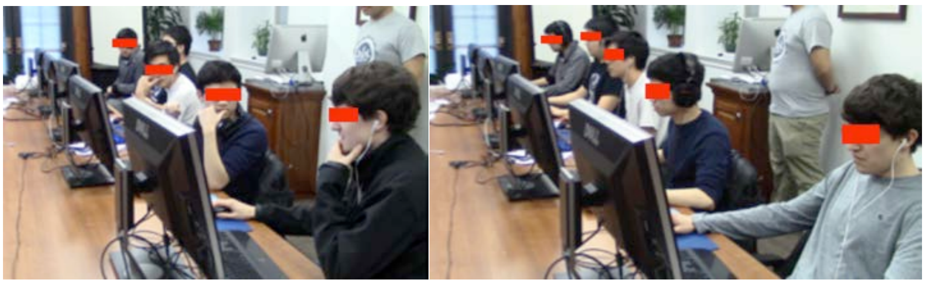

Figure 1. Players on the team and their roles (From closet to the furthest): **C1** - Tank (Top Laner); **C2** - Jungler; **C3** - Mid Laner; **C4** - Attack-Damage Carry (ADC); **C5** - Support / Team Captain. On the left, players are picking their characters before a match, and on the right, they are in the match.

Description of the data

Session participants will view data of one team made up of 5 players during a major collegiate tournament hosted by their home institution (see figure 1). There were a total of 4 teams from the home institution competing, along with 4 teams from universities across the United States. This particular institution did not have official support for e-sports in the form of scholarships or stadiums (which are growing in popularity amongst Big 10 universities; e.g., Tracy, 2017; Wingfield, 2014b) but instead received unofficial support through a student-run organization. We chose to focus on this team because they were the most communicative during the tournament, and thus provided a salient case study of the kind of learning interactions that can be observed during collegiate e-sports play. As college students, team members sometimes had to skip practices, or leave the team in order to deal with other pressing matters, such as schoolwork. This particular team was made up of members who had not significantly practiced together before entering the tournament. However, they won several matches and made it to the finals, so their progression from game 1 to game 3 can be viewed and analyzed for micro-level shifts in verbal and non-verbal collaborative processes and practices.

Game setting

In League of Legends, two teams made up of five people battle it out. The goal of the game is to march to the other team's base with your fellow teammates and minions in order to destroy their Nexus (see figure 2). The players control a character known as a "Champion," of which there are currently 133. Each Champion falls into a different role: Marksmen/Attack-Damage Carry (ADC), Mid-Laner, Tank, Jungler, and Support (see table 1). As one can imagine, there is a complex interplay between each role, and certain characters may even swap roles throughout the course of a match. Further, there exists a large amount of complexity around the basic mechanisms of play. Each champion has 4 skills, natively mapped to the Q-W-E-R keys on the keyboard. Each skill has a different effect, and the "R" skill or "ultimate ability" can be game changing when used strategically. Leading up to a match, the player must choose from a set of masteries and runes that will enhance the statistics and abilities of their champion during gameplay as well. For instance, a Jungler will likely pick masteries and runes that correspond with surviving against neutral monsters and giving bonuses for clearing objectives. Once a player is in control of a champion in game, they must have a "build path" in mind for itemization. League currently has about 200 separate items to choose from in any one match. This shows the complexity of decision-making that any single champion would need to make in order to be successful. Once the enemy team is taken into account, items needed to maximize your own champion's effectiveness along with the ability to counter the enemy's build path need to be considered.

Figure 2. The League of Legends Map (left); The Nexus that the opposing team tries to destroy to win (right).

Table 2: Champion Roles and Mechanics in League

Position	**Description of Position**	**Champion Examples**	**Category**
Top Lane	Chosen for its relative safety, the top lane is typically a solo lane that is filled with characters who specialize in higher health, armor, and/or magic resistance.	Malphite, Maokai, Trundle, Rammus, Ekko, Nautilus, Poppy, Graves, Vladimir	Tank, Bruiser
Mid Lane	Splitting the battlefield in two, the mid-lane provides the closest route to the enemy Nexus. Filled with "Assassin" champions or champions who use special abilities, it has a high impact on the early and mid game.	Zed, Vel'koz, Ekko, Kassadin, Annie, Ahri, Azir, Talon, Vladimir	Mage, AP Carry, Assassin
Jungle	The jungle takes up the most space on the map. Champions here are very mobile and constantly looking for easy ambushes or "ganks" to attack incoming opponents.	Graves, Hecarim, Trundle, Kha'Zix, Kindred, Vi	Jungler (Any role can technically thrive here)

Attack Damage Carry (ADC) ***Bottom Lane***	Primarily located in one half of the bottom lane, the ADC is responsible for killing minions (i.e., in order to "farm") and dominating the enemy ADC and support to build powerful late game items.	Graves, Ezreal, Corki, Ashe, Vayne, Tristana, Jinx, Twitch	Marksman, Assassin, ADC
Support ***Bottom Lane***	On the other half of the bottom lane, the support keeps the team alive and serves to frustrate the opposition. They accomplish this through "slows," stuns, heals, and shields.	Braum, Malphite, Morgana, Nautilus, Brand, Sona, Soraka	Tank, Support, Mage

Expected outcomes and contributions

Through the interactive process of examining the videos, discussing the attributes of multiplayer online battle arenas, and analyzing the collaborative processes in competitive play, participants will gain knowledge of the complexities involved in negotiated learning that can occur during matches, particularly for teams with a mix of expertise. Participants will gain knowledge of the verbal and non-verbal interactions important to understanding team competitive play, domain mastery and negotiation. We further expect that participants will consider the importance of competitive gaming to collaborative learning, particularly with the rise of e-sports in informal and, increasingly, formal learning environments.

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Workshops

Synthesizing CSCL Perspectives on the Theory, Methods, Design, and Implementation of Future Learning Spaces

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Abstract: This pre-conference workshop brings together a number of leading learning scientists, as well as talented younger researchers, working in an emerging, but fragmented line of research focused on 'Future Learning Spaces' (FLSs). Significant advances in this area of scholarship have been made in recent years, spurred by billions of dollars of investments into building or re-designing educational spaces — both physical and digital, formal and informal — to accommodate learning in a networked society. To advance our theoretical understanding on the role of space in learning, vital work remains to be done to frame concepts, synthesize dispersed research agendas and share the results of work that is relevant to the broader FLSs project. To do this, this workshop is organized in four themes that address current challenges and opportunities for FLSs research: Theory, methods, design, and implementation. The workshop includes a combination of invited presenters and key contributors who have advanced research in this area; and active participants, who are interested in deepening their understanding through active participation in the workshop. The objectives of this symposium are to (1) deepen participants' understandings of current FLSs research; (2) cross-fertilize related threads of inquiry for mutual gain; (3) rise above the individual threads to develop syntheses between them; and (4) build collaborative partnerships for future work.

Keywords: CSCL; design; future learning spaces; research-practice-partnerships

The challenge for research on future learning spaces

The accelerating rate of cultural change, spurred by technological innovations, has made the idea of future learning spaces (FLSs) more relevant today than at any time in the past (Adams, Becker, Freeman, Giesinger, Cummins, & Yuhnke, 2016). This comes in the context of the second educational revolution - the first having occurred when brick and mortar schools arose in the industrial age, and the second as society currently transitions from the industrial to the networked society (Collins & Halverson, 2009). Whereas in the past 150 years learners needed textbooks or direct interaction with experts to give them access to specialized knowledge, digital communication technologies have made such access nearly instant. Instructionism — characterized by prescribed curricula, similar assignments for all students, lecturing as the dominant mode of teaching, and externally evaluated standardized exams (Sawyer, 2014) — is being challenged by increasing demands to customize education for the learner. Mass collaboration environments such as Scratch and Wikipedia (Cress, Moskaliuk, & Jeong, 2016), open online courses (e.g., MOOCs, Kahn Academy), the use physical and digital tools for fabrication (e.g., Makerspaces, fablabs) and collaboration (e.g, Knowledge Forum) as well as mobilities between these environments are all widening the space-time dimensions of the prevalent "classroom-as-container" metaphor (Leander, Phillips, & Taylor, 2010). The notion of FLSs represents this shift, whereby learning spaces are conceptualized given the new tools and cultural practices of the networked society.

While there is often a great deal of hype in popular media about new educational architectures and technologies, such ideas frequently overvalue the roles of physical and digital spaces without giving sufficient consideration to computer-supported collaborative learning (CSCL) (Eberle, Lund, Tchounikine, & Fischer, 2015). Over the past several decades, research in CSCL has provided new insights that have significantly shaped our understanding of how people learn. One of the cornerstones of CSCL is its commitment to conducting research that has an impact on practice through research on learning as it happens in real-word contexts, and not in laboratory settings (Barab, 2014). As a result, concepts derived from CSCL are relevant to educational practice, such as learners should be active, collaborative, reflective, and engaged in supportive learning communities and at the same time be provided with sufficient scaffolding or guidance (Vogel, Wecker, Kollar, & Fischer, 2016). Constructing or re-designing learning spaces must surely be informed by the best of what it is that we know about how people learn (e.g., Kimmerle, Thiel, Gerbing, Bientzle, Halatchliyski, & Cress, 2013; Kollar, Pilz, & Fischer, 2014). For this symposium, we aim to bring together a range of expertise from this applied body of research.

CSCL does not only offer a vital body of knowledge that should serve as foundation for FLSs, it also provides a theoretical perspective that brings together the ideas of "future" and "learning" with "spaces". Specifically, a main thrust of CSCL has been an approach that emphasizes every day, culture-dependent social interactions and their role in learning (Lave & Wenger, 1991). From this sociocultural perspective, learning is seen as a process of becoming a full member of a knowledge building community. If we want to prepare students to take their place as professionals in the age of innovation, then we need to facilitate their participation in authentic collaborations, to creatively resolve complex problems, through learning activities that provide access to authentic professional practices (Radinsky, Bouillion, Lento, & Gomez, 2001). Traditional schooling has developed its own culture, with practices such as standardized tests and homogenous grouping, which are founded upon strong but often unsubstantiated assumptions of learning (Brown & Campione, 1994). As a result, students often acquire knowledge and practices that are useful to succeed in schools, but have little relevance to what they do in the professional world (Brown, Collins, & Duguid, 1989). Socioculturally based educational designs, such as collaborative learning, productive failure, inquiry-based, problem-centered learning or learning communities, are central to bringing the innovation age into the classroom and should therefore be used to guide the design of FLSs (Hod & Sagy, 2016; Loibl & Rummel, 2015).

Innovative CSCL research in FLSs, grounded in these perspectives, is already underway (e.g., Hod et al., 2016). For example, Lui and Slotta (2014) turned an ordinary classroom into a virtual rainforest so that students could engage in the types of collaborative activities and practices of evolutionary biologists. Zhang and colleagues (2015) developed new digital tools that support distant classroom communities to engage in shared knowledge building on topics such as climate change and human body systems. Despite its immense practical implications, this topic remains on the periphery of the field. The main research journal (ijCSCL), has scarcely published any articles related to FLSs. Furthermore, scholarship on this topic is dispersed and fragmented, leading to slow progress in both theory and practice (Ellis & Goodyear, 2016). It is therefore our intention to use this workshop, not only as a shared venue for collaboration, but as a way to build a serious line of inquiry in FLSs within the broader CSCL community.

Workshop themes, structure, and goals

Themes of FLS research for this workshop

This workshop aims to synthesize perspectives from CSCL on FLSs around four main themes of research, each with three focal questions, to be addressed at the workshop (see table 1).

Table 1: Main workshop themes and related questions

Theme	Key questions
Theory	How do we conceptualize key FLS constructs like future, learning, and space? What theoretical or conceptual frameworks do we have to think about FLSs?
Methods	What methods can be used to investigate FLSs? What can different methods tell us, and what are the limitations of each method? What are the key challenges when we look across these methods?
Design	What counts as a FLS? What are the different designs of FLSs, and how can we rise above the variations to categorize them? What are key principles in the design of FLSs so they support learning?
Implementation	What frameworks do we have to best think about implementing local FLSs and scaling ups? What is unique about research-practice partnerships for FLSs compared with other domains, such as educational technologies? How can it be ensured that new FLSs prioritize equity and give access to all?

Workshop structure

The workshop is organized in the following four sections, supported by activities before and after the face-to-face meeting:

Section 1 - Building Community

The group will engage in an ice-breaking experience and sharing activities to (a) explore everyone's interest and background on the topic; (b) build group cohesion; and (c) make sure that new members are given a legitimate place in the group.

Section 2 - Advancing Knowledge about Future Learning Spaces

The group will engage in orchestrated activities with the purpose of (a) giving all the participants a chance to deepen their knowledge about each topic and discuss relevant issues; and (b) providing each theme-based group with extensive feedback and ideas for how to advance. Specifically, members of each theme will present the central ideas and challenges related to their topic. Following discussion and feedback, there will be several rounds of cross-theme interaction between groups so that members of each theme can provide feedback and advance their knowledge on different topics. After several rounds, groups will return to their original themes to collate feedback, discuss issues, and present collective advancements in their topic.

Section 3 - Reflections and Plans for the Future

The group will engage in a whole group discussion as well as closing activity to (a) reflect on what has been learned, both individually and collectively, and (b) to plan future activities.

Workshop goals

This workshop has three interdependent goals, at the micro-, meso-, and macro-levels. At the micro-level, the goal is to advance the FLSs research of the participants. Invited presenters and key contributors will leave the workshop with articulated strengths and challenges for future research. Active participants will leave with questions and concrete ideas for new research. At the meso-level, we will put together a proposal for a special issue in a CSCL-related journal on the topic of FLSs. This will help to establish collaborative activities after the workshop and guide future activities that contribute to the scientific landscape of FLSs. The special issue will be used as a springboard into further collaborations at the macro-level. Specifically, we are committed to an international FLSs effort, aimed at bringing together dispersed FLSs researchers from across the world around this line of inquiry. We have allocated time in this workshop to ensure that these goals are advanced (section 3 of the agenda). This includes plans for collaborative research between individual researchers, as well as at the institutional levels for continued collaboration. For example, we aim to explore a partnership between the Canadian, Israeli, German, Australian, and American scholars involved in the workshop.

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Publishing in the Learning Sciences: A Journal Writers' Workshop

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Abstract: Quality writing is essential for the growth of the Learning Sciences (LS) and research dissemination. However, many scholars struggle with writing and lack the mentoring to translate their research ideas and activities into prominent LS publications. Editors from JLS and ijCSCL propose to conduct a half-day workshop that fosters a writing culture among a cohort of learning scientists. Selected participants must be actively working on a manuscript poised for submission to an ISLS journal, and lacking the appropriate mentoring resources. The workshop activities address general journal writing tips and review process information, as well as one-on-one time spent between participants and their editor-mentors focused on the participants' specific writing project. Take-aways include participation in a journal writers' support network and a mentorship relationship that can extend beyond the conference.

Description and duration

> *When you write, you lay out a line of words. The line of words is a miner's pick, a woodcarver's gouge, a surgeon's probe. You wield it, and it digs a path you follow. Soon you find yourself deep in new territory. Is it a dead end, or have you located the real subject? You will know tomorrow, or this time next year. You make the path boldly and follow it fearfully. You go where the path leads. At the end of the path, you find a box canyon. You hammer out reports, dispatch bulletins. The writing has changed, in your hands, and in a twinkling, from an expression of your notions to an epistemological tool. The new place interests you because it is not clear. You attend. In your humility, you lay down the words carefully, watching all the angles. Now the earlier writing looks soft and careless. Process is nothing; erase your tracks. The path is not the work. I hope your tracks have grown over; I hope birds ate the crumbs; I hope you will toss it all and not look back.*
>
> -- Annie Dillard, *The Writing Life*

Quality writing is essential for the growth of the Learning Sciences (LS) and research dissemination. However, many scholars struggle with writing and lack the mentoring to translate their research ideas and activities into prominent LS publications. Becoming a writer is a lifelong process of growth and professional development and it needs to be explicitly cultivated within the LS community. Mentoring within the field is critical for the healthy growth of LS (Nathan, Rummel, Hay, 20106). As the editors of the ISLS journals, we seek to address this gap between our community needs and its current offerings through a half-day pre-conference workshop for scholars who experience one or more of the issues outlined above. The half-day workshop will be structured as follows:

1. Following introductions, participants will learn a method for self-reviewing their own research papers for alignment with the paper's (a) research questions or hypotheses; (b) proposed theory of action, (c) method section, including all data collection, and (d) data analysis and research findings (see Table 1).
2. The next hour and a half would be dedicated to one-on-one mentoring with an ISLS editor. Where two mentees are assigned, time is split for one-on-one mentoring each for 30 minutes, followed by the triad.
3. For the next hour, participants report out to the whole workshop on specific next writing steps.
4. For the last 30 minutes, there will be a presentation from the ISLS editors, open to all conference attendees, Editors will share journal guidelines, demystify the review process, highlight common issues in decision letters, and answer questions. This will be followed by the New Members' Workshop, when the traditional editor's panel will be held. All workshop participants are invited to attend.

Table 1: A table for author self-review showing the alignment or missing elements of a research paper

	Research Questions & Hypotheses	Theory of Action (incl. theory elements)	Methods (incl. all data collection, measures)	Data Analysis & Results
RQ1	I hypothesize …			
RQ2				

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We are editors of the International Society of the Learning Sciences (ISLS) journals who recognize a need to build capacity within our community for writing and to support the growth of a writers' culture in ISLS. Sten, Susan, and Jan are the editors-in-chief, respectively, of the *International Journal of Computer Supported Collaborative Learning*, and *The Journal of the Learning Sciences*. The other organizers are associate editors in *JLS* and *ijCSCL*. We have shared experience chairing the conference and conducting conference workshops.

Themes and goals

Growing the Learning Sciences: Fostering a writing community

The Learning Sciences is an international, multicultural, multidisciplinary field that engages in innovative research and development. While our community strives to offer many avenues for sharing our research findings, journal writing is a central to our communal growth and impact. We recognize that writing is a challenging intellectual activity – few of us our "natural" writers – and the Society as a whole benefits from a shared commitment to improve the writing proficiencies of all of our colleagues. Furthermore, the current convention of English as the official language of our international journals, *The Journal of the Learning Sciences* and the *International Journal of Computer Supported Collaborative Learning* creates systemic inequities for our members and other scholars seeking to contribute to the Learning Sciences literature. We propose to help address these important needs with A Journal Writers' Workshop, a half-day, pre-conference workshop that provides participants with practical, hands-on tools and methods for improving their writing processes and products. Our approach is informed by research on writing and the importance of entering into a community of practice that provides continued support beyond the time limit of the CSCL conference.

Equitable representation in ISLS journals

Although ISLS is an international society, which holds its annual conferences in countries around the world, there are very few international or non-native English-speaking scholars published in ISLS journals. There are several reasons for why this situation has persisted. First, relative to the membership, there are comparatively few manuscripts submitted from regions in which English is not the academic language. Second, the manuscripts that are submitted from these regions often do not follow the norms and standards of high quality academic writing that are required to be published in ISLS journals. Third, in many cases, we know that scholars in these regions do not have access to mentors and research environments to support their writing.

A powerful technique used by ESL adults learning to improve their writing is collaborative writing (Storch, 2005). Those working in pairs produced texts that were more concise, had fewer grammatical errors, and better matched the task goals. Several processes in the collaboration contributed to this, including more frequent and useful feedback by their writing partner and the opportunity to pool relevant ideas together to improve the document.

Writing as a lifelong skill

Writing is an ill-defined problem (Hayes, 2000), rich with hidden processes that belie its final structure. Glynda Hull and Mike Rose (1989) note that while many teachers acknowledge the importance of writing as process, in many cases the iterative nature of the writing process is often hidden. Many young writers engage in knowledge telling, a linear reporting of all one knows about a topic. Yet skillful writing requires *knowledge transforming* (Bereiter & Scardamalia, 2013), which includes careful planning and reflectively organizing content through the filters of rhetorical knowledge that takes into account both the audience and the topic. Flower and colleagues (1992) delineate many of the practical elements of skillful, reflective writing by explicitly addressing topic, purpose, audience, and text conventions, and by explicitly writing with revision in mind.

Expected outcomes and contributions

Our expectation is that this will provide a rich professional development experience for a cohort of writing fellows who will grow their capacity to generate high quality research papers for the Learning Sciences community. We need to be in this for the "long game," with careful attention dedicated to a cohort of manageable size to achieve initial impact and success, and to start to develop an effective model for building up a writing culture within ISLS. Our mode is that this initial experience builds a foundation for continued mentoring and correspondences between the participants and their editor-mentors. While we set out to reach a group of 20 (with ten mentors), we believe that this could become a recurrent workshop at CSCL and ICLS conferences, and provide direct impact for a much larger group in the years to come.

Relationship to other events

Within ISLS, this has some similarity to the Early Career Workshop (ECW) and Doctoral Consortium (DC). This also has similarities to the AERA Division C Graduate Seminar, and the AERA New Faculty Mentoring Program. This workshop does provide some shared professional development with those events, because writing for journals is a highly desirable skill in our community and is greatly needed for ISLS scholarship to flourish. We distinguish this workshop from others in the focus of mentoring specifically on a current piece of each participant's writing, the orientation of that writing for a Learning Sciences audience, and the selection preferences for those scholars who are from underrepresented regions of the world and lack access to mentors.

Intended audience and participant requirements and facilities

We will advertise for participants to apply on the CSCL 2017 website. Preference will be given to applicants who (1) are actively involved in writing or revision a paper for the *International Journal of Computer Supported Collaborative Learning*, or *The Journal of the Learning Sciences*; (2) indicate that they are from an underrepresented region of the world and/or do not have access to LS mentorship; and (3) those who have completed their graduate degree. Applicants need to provide a current CV, the title and abstract for their working paper, a writing sample, their goals for attending the workshop, and their research areas of interest so that we can most closely match them with an appropriate editor-mentor. If selected, participants will submit current writing sample that will be part of the workshop activities. We will select up to 20 participants.

Our recruitment strategy will include contacting the organizers of CSCL 2017 and sending announcements using the listservs for ISLS, EARLI, and AERA. We provide a draft call for this workshop.

> We invite Learning Sciences scholars to apply for participation in "A Journal Writers' Workshop," which will be held prior to CSCL 2017 in Philadelphia, PA (USA). This workshop provides an intimate opportunity to receive mentoring from ISLS editors on a specific writing project that is slated for one of the ISLS.org journals, general understand of the writing and journal review process, and meetings with other scholars in your workshop cohort who, along with your assigned mentor, could play a role in your future writers' support network. Preference will be given to applicants who (1) are actively involved in writing or revision a paper for the *International Journal of Computer Supported Collaborative Learning*, or *The Journal of the Learning Sciences*; (2) indicate that they are from an underrepresented region of the world and/or do not have access to LS mentorship; and (3) those who have completed a graduate degree.

Facilities and equipment required

Our workshop will need space for 35 to accommodate up to 20 participants and their 10 editor-mentors, and the workshop organizer and co-facilitators. We require a projector system for participants' laptops, and movable tables and chairs in order to accommodate one-on-one, small group, and whole group configurations. We will need participants' email addresses to make pre- and post-workshop contacts between mentors and participants.

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Emergent Practices and Material Conditions in Tablet-mediated Collaborative Learning and Teaching

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Abstract: The way in which digital technologies take part and contribute to configuring teaching and collaborative learning practices has become a timely research matter in our field. Current studies in the CSCL field, and particularly on the use of tablets in education, draw attention to how everyday educational practices are entangled with contemporary technologies and, how these technologies shape in turn such practices, in schools and higher education. This half-day workshop aims specifically at accounting for emergent practices in tablet-mediated collaborative learning and teaching, with a particularly focus on the material conditions that constitute such practices. The workshop invites researchers, designers and practitioners to contribute and engage with in-depth analyses of the use of tablets in everyday teaching and learning, in schools and higher education contexts. Furthermore, the workshop intends to trigger and facilitate participants to generate/propose conceptual and methodological analytical tools for examining the material conditions of tablet-mediated collaborative learning and teaching practices. The outcomes of the workshop will consist of (1) a repertoire of (identified) emergent practices bounded to the use of tablets in schools and higher education, reported by the participants, (2) a set of conceptual and analytical tools for the study of material conditions of CSCL practices and (3) a network bringing together researchers, practitioners and designers to set up a research agenda and initiate a consortium including the organisation of a special issue in an International journal.

Keywords: tablets, empirical studies, schools, higher education, CSCL practices, CSCL artifacts, materiality of learning, sociocultural theory, instrumental genesis theory.

Organizers' background

The organizers conduct research in the field of CSCL and represent different countries. Together, they bridge North American, South American and European communities. The organizers have a large experience in organizing workshops at several International conferences such as EC-TEL, ACM GROUP, NordiTEL, Participatory Design, Designs for Learning, Kaleidoscope TELEARC, Mobile HCI, EARLI, ICLS and CSCL.

Two organizers of the present proposal conducted a first workshop on tablets at CSCL 2015. This workshop brought together more than 20 people and generated 12 International contributions, that are documented on this previous workshop's website (https://sites.google.com/site/tmclpractices/home/tmcl2015-workshop). While the first workshop on the use of tablets identified a range of CSCL practices in schools, the proposed workshop aims at analyzing and conceptualizing everyday educational practices by placing a particular focus on the material conditions of such practices as they unfold in schools and higher education contexts.

Introduction

In recent years, an increasing number of research studies has been exploring the potential and the implications of the use of mobile technology and media tablets in schools (Traxler, 2010; Sharples, Taylor, & Vavoula, 2010; Jahnke & Kumar, 2014; Cerratto-Pargman & Milrad, 2016). Most studies have focused on issues pertaining to learning efficiency (Roschelle et al., 2005), motivation (Kim & Frick (2011)), knowledge acquisition (Lai et al., 2007) and inquiry-based learning (Haßler et al., 2014). Although these issues are compelling and important, they limit the study of technology in education (Sörensen, 2009). First, they often treat technology as disembodied from learners' or teachers' everyday practice (Hakkarainen et al., 2015; Cerratto, 2000; Cerratto-Pargman et al., 2015, Nouri & Cerratto-Pargman, 2016). Second, they approach technology in terms of the suitability of a specific technology for serving a predefined learning or teaching purpose. On this note, Sörensen (2009) underscores the fact that researchers in education often tend to "first consider how children learn and develop and what characterizes good interaction, and only after they ask how technology can be applied to create these conditions. Researchers rarely consider that it may be the other way around: that we theorize about learning the way we do because we have certain learning materials in mind when we account for learning" (p.7).

Theoretical approaches

The workshop draws attention to the material conditions for tablet-mediated collaborative learning and teaching practices and relates closely to the organizers' interest in the relationship between *tools/technology* and *learning* (Säljö, 2010; Sörensen, 2009). Within this relationship, learning gains materiality through the use of tools/technology and, consequently, such materiality has implications for learning, as it transforms "how we teach and learn as well as how we come to interpret learning" (Säljö, 2010, p.53). Situating learning and teaching into the material world brings us to view these activities as embedded within sociocultural activities that are bounded to tools that make them possible (Säljö, 2010; Rabardel, 1995). Such interest in the imbrication between material, cognitive and social aspects of teaching and learning activities is not really new; it has for instance been the object of study within a) the cultural historical approach (Vygotsky, 1934/1997), b) the instrumental genesis theory (Rabardel, 1995; Lonchamp, 2012) and c) the sociomaterial lens on learning (Sörensen, 2009; Fenwick et al., 2011). These three approaches constitute the theoretical underpinning of this workshop. More specifically, Vygotsky's (1934/1997) notion of *mediation* raises the attention and points at the need for conducting situated studies, able to scrutinize the interaction between humans and tools. Taking heed of how tools (e.g., either psychological or technical) restructure the capacities of the human mind, Vygotsky (1997) introduced the *instrumental act* in order to explain how the inclusion of a tool into a human activity reorganizes such activity. Rabardel's (1995) concept of the *instrument* challenges us to look at tools-in-use as artifacts that are elaborated in complex processes where the material, technical part (i.e. its design and affordances) is intertwined with the subject's utilization schemes or behavioral part (i.e. user's representations, knowledge and practices). Finally, recent sociomaterial conceptualizations of learning (Sörensen, 2009; Fenwick et al., 2011) renew the interest in the relationship between technology and learning from stances that criticize tools viewed as disembodied from current educational practices.

With this workshop, we aim to expand current understandings of material conditions of learning and teaching through analytical accounts of emergent practices bound to the use of tablets in schools and higher education.

Guiding topics (but not limited to) are:

- Case studies of emergent tablet-mediated teaching practices
- Conflicts between established (existing, traditional) and emergent new teaching and learning practices
- Tensions between use of analog and digital tools in the classroom ecology
- Reflective accounts of unexpected uses of tablets in schools and higher education
- User studies focused on transformations of everyday practices in education
- Methodologies for the analysis of the materiality of tools
- Empirical grounded reflections about the transformational and performative nature of learning
- Conceptualization of interdependences between human agency, minds, bodies and technologies
- Theories, models, methodologies for studying tablet-mediated practices.
- Socio-technical/socio-material design approaches
- Design and use of innovative mobile applications such as Augmented Reality technologies

Different types of contributions are welcomed, ranging from work in progress, results from finalized projects conducted in schools or higher education, as well as practitioners' reports accounting for tablet-mediated practices in educational contexts. Authors are invited to submit original unpublished research as extended abstracts (max. 2 pages). Position papers are expected to include a description of the learning situation studied, the theoretical underpinnings of the work, the methodology applied, and if available, results and implications. Since the approach is interdisciplinary, the workshop seeks to attract different categories of participants, including students, researchers in schools, designers, practitioners and developers. Papers reviewed and selected by the Program Committee will be published on the workshop website: https://sites.google.com/site/tmclpractices .

Goals

This workshop will contribute to a deeper understanding of how material conditions of tablets shape current understandings of everyday learning and teaching practices in schools and higher education. More specifically, three goals structure this workshop: a) to identify how tablets configure teaching and learning practices, b) to analyze the material conditions of tablet-mediated teaching and learning practices, specifying the methods or analytical concept applied, c) to conceptualize the entanglement of material and behavioral/social aspects of learning and teaching practices mediated by tablets.

Expected outcomes and contributions

The workshop invites participants to further elaborate on how the design of technologies such as tablets and their apps configures current teaching and learning, also in unexpected ways and including accounts of how technologies fail in education (Boyd, 2002). The outcomes of this collaborative knowledge-building session will result into (1) a repertoire of emergent practices bounded to the use of tablets in schools and higher education, (2) a set of conceptual tools and methods for the study of material conditions of CSCL practices and (3) a research agenda and a consortium concerned with themes and studies that aims to "account for emergent practices and material conditions for teaching and learning in the 21 century". (4) Selected contributions will be published in a special issue organized by the workshop's organizers.

Intended audience

The intended audience of this workshop are researchers, designers and practitioners (e.g. teachers), who engage in or are in some way involved in work with tablet-mediated teaching and learning, conduct research in schools and/or higher education and have backgrounds in different disciplines, such as Computer Science, Cognitive Science, Learning Science, Science and Technology Studies, Educational Technology, Design and Applied Educational Science.

Workshop format

The papers accepted by the program committee will be clustered in themes that will, in turn, be used for scaffolding knowledge building during the workshop. The workshop will consist of three sessions: an *inspiration event*, a *working group* session and *plans* for the future. The *inspiration event* will consist of participants' presentation of their position statements in the Pecha Kucha format. The Pecha Kucha event is based on a simple idea: each presenter presents 20 slides in 20 seconds each (approx. 6' 40" in total). It is a presentation format that gives more presenters the chance to share their research. The inputs from the Pecha Kutcha session will be used to inspire discussions for the working group session. During the *working group session*, discussions will be facilitated by the workshop organizers utilizing the method of the "World café" which entails short round tables discussing pre-prepared questions identified during the inspiration event (10 min. per table), then the groups will mix up in new groups and go to another table in order to discuss a new question. The session about *plans* for the future will bring the groups to discuss main ideas and outlines for a research agenda and consortium. The workshop format requires 4 hours and 30 min in total (including breaks).

Dissemination activities

The workshop will bring together international researchers, designers and practitioners who work on/with tablet-mediated teaching and learning and are interested in analyzing and conceptualizing the material conditions of practices associated with such teaching and learning. The dissemination activities will exploit a range of social media for the viral spread of information, including Twitter (#TMCL2016), a Facebook group set up in 2015 in our first CSCL workshop (https://www.facebook.com/groups/TMCL2015/), personal blogs (by the organizers), social media networks and our website: https://sites.google.com/site/tmclpractices. The workshop is set out to attract high quality submissions from various communities, and to be a point of departure in developing a research agenda and in building a sustainable and International network of stakeholders. In order to guide further discussion in the community and spin off creative initiatives, the workshop resources, including accepted abstracts, Pecha Kutcha presentations, will be available on the main website: https://materialconditionsblog.wordpress.com/

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Enabling and Understanding Embodied STEM Learning

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Abstract: Theories of embodiment offer challenges to educational research and practice in ways that could potentially both reveal and support processes of teaching and learning in populations otherwise underserved. In particular, we focus on the 2017 conference theme *Making a Difference: Prioritizing Equity and Access in CSCL* by sharing with the CSCL community our varied approaches for designing learning contexts that provide diverse students movement-based experiential entry points to STEM content. In our pursuit, we recognize that core content notions may initially emerge for students through participating in problem-solving activities that complement traditional verbal and symbol sign systems with corporeal–dynamical modalities. Drawing on our workshop participants' research goals, we will facilitate activities oriented on grasping key ideas for theory, methods, and design.

Perspective

Embodied cognition offers learning scientists new perspectives on design, research methods, and learning theory. Embodied cognition is growing in theoretical importance and as a driving set of design principles for curriculum activities and technology innovations for STEM education. The central aim of this workshop is to attract engaged and inspired colleagues into a growing community of discourse around theoretical, technological, and methodological developments for advancing the study of embodied cognition and STEM.
This workshop focuses more precisely on three aspects of embodied cognition and STEM:

Rationale

An important consideration in embodied cognition for STEM is the interplay between disciplinary STEM content and theoretical apparatus (e.g., supporting physics vs. engineering learning may have different constraints). Embodiment offers a powerful alternative way of framing the interplay of subject matter content for education and learning theory. One way it does this is by identifying STEM notions and systems of notation (e.g., diagrams and symbolic formalisms) as shared physical experiences rooted in our common physiology, such as articulated hands (gestures), bilateral organization (symmetry), stereoscopic vision (perspective), and ambulation (navigation in 3D space). Abstractions in math, science, engineering, and art arise from these common experiences as grounding forms of lived, phenomenological experiences, rather than transcendent idealizations. In sum, we highlight the importance of bringing novel approaches to the critical area of STEM education.

Design frameworks and technical instrumentation

We are also interested in the nitty-gritty details behind designing and analyzing interventions and classrooms with embodied cognition as the driving theory. A variety embodied interventions for STEM learning have recently emerged, using devices like digital dance mats (Fischer, Link, Cress, Nuerk, & Moeller, 2015), motion capture technology (Nathan & Walkington, in press; Smith, King, & Hoyte, 2014; Trninic & Abrahamson, 2012), touch screens (Ottmar, Landy, & Goldstone, 2012), mixed reality simulations (Enyedy & Danish, 2015; Lindgren, 2015), global positioning systems (Hall, Ma, & Nemirovsky, 2015), and video game consoles (Williams-Pierce, 2016). We acknowledge the enormous amount of design work that goes into creating embodied STEM interventions, in particular as this is a recent, rapidly developing area with an extremely limited knowledge base. Designing learning environments for embodiment necessitates designs for motor and sensory systems that are not merely perceiving and acting *in service of* cognition, but *as* cognition. Environments with these design considerations attend to the ways new forms of enactment of our body-minds register with our learning objectives (Abrahamson & Bakker, 2016).

Equity

Embodied cognition calls for expanded ways of assessing knowing and learning, as it looks to nonverbal conceptualizations, and challenges assessment practices that disengage and penalize body-based ways of expressing and communicating (such as computer-based typing). This workshop will focus on ways in which the CSCL community can widen definitions of learning to encompass new environments, methods, and ways of demonstrating understanding. We believe that this widening will also support the CSCL and broader communities in perceiving knowledge in learners that may otherwise go unnoticed and un-valued. This is relevant given the importance of promoting achievement for students from many ethnic backgrounds, geographic regions, and socioeconomic circumstances. There is a need to articulate evidence-based findings and principles of embodied cognition to the research and development communities who are looking to generate and disseminate innovative programs for promoting STEM learning through embodiment.

Audience

The intended audience for this workshop is CSCL attendees who are looking to expand the notion of learning to further provide for body-based action and communicative gesture, as they struggle to account for certain learning phenomena that are generally analyzed with spoken and written language as the primary assessment orientation. We are also aiming for researchers who are conducting STEM research with an embodied cognition perspective, or are new to the field but interested in better accounting for components of embodied cognition within their STEM work. In particular, we anticipate attendees who wish to engage in hands-on activities that support learning about the practicalities of doing embodied cognition research and analysis in STEM.

Event description and schedule

This workshop is designed as a full day event crafted around the participants' interests, as determined through the online application. Participants will be asked to state: which of the STEM fields have they conducted research in, and which they are interested in; what their previous experience with embodied cognition is; what aspects of STEM and embodied cognition research they are particularly interested in learning more about (e.g., coding gesture data; coding multimodal discourse and video data; designing embodied technology interfaces such as iPads or Kinect, etc.); and whether they have artifacts or research goals they would like to contribute to.

The workshop will be designed based upon the collective responses from the application form. For example, if a participant who has become newly interested in embodied cognition would like to examine their previously collected data through a new lens that places value upon nonverbal communication, and other participants indicate interest in coding that type of data, we will organize an activity around analyzing those data, with guidance from the appropriate workshop organizer(s) to assist in developing a productive small group. Another example might be a participant who has a research question they would like to design a learning environment around – and others who would like to experience the process of designing learning environments for embodied STEM experiences. We have a strong team who can facilitate these types of experiences, as well as provide data, research questions, and design challenges if the applicants are unable to do so. We also anticipate the following broader areas of interest may emerge: how supporting STEM learning through movement can increase more equitable participation in STEM fields; the "Internet of Things" (physical and digital blending), and how it might influence learning across people who are not co-located; the role of haptic feedback (or lack thereof); the role of communicative gestures in revealing learning; the design-based research cycle when designing for embodied cognition and STEM learning; and designing embodied coordination spaces that explicitly construct and provide access to connections across and between representations.

Proposed schedule:

- 8:30 am: Welcome; Quick framing of the workshop; Organizers' introductions
- 8:45 am: Minute Madness – each participant presents 1 slide about themselves in 1 minute
- 9:15 am: Demonstration activities – the organizers will provide three different examples of STEM activities designed to support embodied learning (for example, Candace Walkington will demo a motion capture Kinect game for learning geometry), and participants will rotate through
- 10:00 am: Break
- 10:15 am: Participants will be organized into small groups based upon their application forms, and engage in their first hands-on workshop
- 12:30 pm: Lunch/break

- 1:30 pm: Participants will be organized into different small groups based upon their application forms, and engage in their second hands-on workshop
- 3:30 pm: Break
- 3:45 pm: Participants will convene in small jigsaw groups and share what they learned and did thus far. The groups will be designed to be cross-cutting in thematic way, likely by STEM content group, so that those interested in Science, for example, can share their workshop experiences and discuss the application of what they learned to embodied cognition science research
- 4:45 pm: Small groups will share out to the whole group, and discuss ways to continue as a community after CSCL. Participants will discuss their research interests moving forwards related to embodied STEM, discuss opportunities for cross-institutional collaboration on educational research, create a list of research questions they are interested in exploring, and discuss inter-relations among different participants' interests
- 5:30 pm: Conclusion

As a narrative illustration of a participant's experience, we present a short vignette. Meet Jordan, a hypothetical assistant professor who studies engineering education, and is in the midst of developing a professional development (PD) course for high school engineering teachers. Jordan has read Nathan et al.'s (2013) article, and is looking for the opportunity to discuss how *threading through* could be supported in PD contexts.

Jordan's application asked for hands-on experience analyzing multi-modal gestures in video data, and that is the first workshop they are assigned to. Another participant brought data of a dyad playing a video game together, and hands out a single page handout that introduces the framing of the study the data is from. Two of the organizers facilitate the workshop, discussing different approaches to analyzing the data. For example, analyzing the gesture without sound, first, so the focus is purely on the physical gestures, then analyzing the sound without the video, then combining the two, so that physical gesture and verbal language are each given equal weight in the analysis. Another method focuses on the digital actions within the game itself, and treats those actions like gestures. The workshop participants are split up into small groups that each take a different method of analysis to the same video clip, and guided by an organizer. After hands-on analysis, the groups come back and discuss their impressions of the data, and the group as a whole discusses how the different approaches influence what is revealed in the data. Jordan leaves the workshop with a specific plan for analyzing the PD data, and an understanding of what that approach will privilege in the data.

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EPCAL: Computer-Supported Collaboration at Scale

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Abstract: Large-scale collaborative activities require non-trivial technological infrastructure. Educational Testing Service (ETS) has made a major investment in developing the ETS platform for collaborative assessment and learning (EPCAL) to facilitate empirical studies at large-scale. In this workshop, we introduce the EPCAL platform to the participants via a set of pre-designed collaborative learning/assessment activities hosted on the platform. Participants will team up in dyads or triads on the EPCAL platform to complete these tasks collaboratively. We will facilitate discussions on common challenges and solutions regarding the design of collaborative learning and assessment environments and how the EPCAL platform can be used to support various needs of such designs.

Keywords: web-based platform, large-scale collaboration, standardization

Organizers' names and backgrounds

Dr. Jiangang Hao is a senior research scientist in the R&D Division at Educational Testing Service. His current research centers on collaborative problem solving, game and simulation-based assessment, educational data mining & analytics, and automated annotation/scoring. He is leading the computational psychometrics sub-initiative of the FASP initiative at ETS, and is the principal investigator of ETS's collaborative science assessment prototype (ECSAP) as well as the ETS platform for collaborative assessment and learning (EPCAL). He leads the development of the assessment data analytics solution (glassPy) at ETS and is the recipient of the 2015 ETS presidential award. Dr. Hao obtained his Ph.D. in Physics and MA in Statistics, both from the University of Michigan. He has published over 50 peer-reviewed papers and developed several widely used software packages in Python and C++ for image analysis; measurement error corrected Gaussian Mixture Model and Probabilistic clustering analysis. His work has been widely reported by leading technology media, such as the Wired and MIT Technology Review.

Dr. Lei Liu is a research scientist at the Student and Teacher Research Group at Educational Testing Service. She is leading and co-leading multiple projects focusing on the design of innovative and technology-rich science assessments that are competency-based and NGSS aligned. Her research has drawn heavily on cognitive and socio-constructivist learning theories. Her research interest is on the role of technology in learning and assessing. She has developed the simulation-based learning environment and assessments, learning progression-based assessments, conversation-based assessments, and collaborative problem-solving assessments. She has published over forty peer-reviewed articles on topics including science assessment, technology-enhanced learning and assessment, and collaborative learning, including top journals like Journal of Research in Science Teaching, Journal of the Learning Sciences, Journal of Educational Measurement.

Dr. Jessica Andrews is an associate research scientist in the Cognitive, Accessibility, & Technology Sciences Center in Research at Educational Testing Service in Princeton, NJ. She received her Ph.D. degree in learning sciences from Northwestern University. Her research examines the cognitive processes underlying collaborative learning, focusing on how people acquire accurate and inaccurate information during their collaborative experiences. The second line of research explores the use of technological environments (e.g., learning management systems, games, simulations) in supporting student learning and assessing individuals' cognitive and non-cognitive (e.g., collaborative) skills. She is the principal investigator of an NSF grant aimed at using an online collaborative simulation-based task as a standalone assessment of students' electronics content understanding and collaborative problem-solving skill.

Dr. Diego Zapata-Rivera is a Senior Research Scientist in the Cognitive, Accessibility and Technology Sciences Center at Educational Testing Service in Princeton, NJ. He earned a Ph.D. in computer science (with a focus on artificial intelligence in education) from the University of Saskatchewan in 2003. His research at ETS has focused on the areas of innovations in score reporting and adaptive learning and assessment environments including game-based and conversation-based assessments. His research interests also include Bayesian student modeling, open student models, virtual communities, authoring tools, and program evaluation. Dr. Zapata-Rivera has produced over 100 publications including journal articles, book chapters, and technical papers. He has served as a reviewer for several international conferences and journals and has been a committee member and organizer of international conferences and workshops in his research areas. He is a member of the Editorial Board of User Modeling and User-Adapted Interaction and an Associate Editor of the IEEE Transactions on Learning Technologies Journal.

Dr. Alina von Davier is the Vice President of ACTNext by ACT, Inc., a Research, Development, and Business Innovation Division, as well as an Adjunct Professor at Fordham University. She earned her PhD in mathematics from the Otto von Guericke University of Magdeburg, Germany, and her MS in mathematics from the University of Bucharest, Romania. At ACT, von Davier and her team of experts are responsible for developing prototypes of research-based solutions and creating a research agenda to support the next generation for learning and assessment systems (LAS). She pioneers the development and application of computational psychometrics and conducts research on blending machine learning algorithms with the psychometric theory. Prior to her employment with ACT, von Davier was a Senior Research Director at Educational Testing Service (ETS) where she led the Computational Psychometrics Research Center.

Dr. Art Graesser is a professor in the Department of Psychology and the Institute of Intelligent Systems at the University of Memphis, as well as an Honorary Research Fellow at the University of Oxford. He received his Ph.D. in psychology from the University of California at San Diego. His research interests question asking and answering, tutoring, text comprehension, inference generation, conversation, reading, problem-solving, memory, emotions, artificial intelligence, computational linguistics, and human-computer interaction. He served as editor of the journal Discourse Processes (1996–2005) and Journal of Educational Psychology (2009-2014), as well as presidents of 4 societies, including Society for Text and Discourse (2007-2010), the International Society for Artificial Intelligence in Education (2007-2009), and the Federation of Associations in the Behavioral and Brain Sciences (2012-13). He and his colleagues have developed and tested software in learning, language, and discourse technologies, including those that hold a conversation in natural language and interact with multimedia (such as AutoTutor) and those that analyze text on multiple levels of language and discourse (Coh-Metrix and Question Understanding Aid -- QUAID). He served on OECD expert panels on problem-solving, namely PIAAC 2011 PS-TRE, PISA 2012 Complex Problem Solving, and PISA 2015 Collaborative Problem Solving (chair).

Workshop description

Most of the existing studies on collaborative learning and assessments are designed to reveal important aspects or patterns of collaboration (Cohen et al., 1999; DeChurch and Mesmer-Magnus, 2010; O'Neil, 2014) based on small samples of participants (von Davier & Halpin, 2013). The items/tasks used in these studies are generally not standardized. The convenience sample and the non-standardized items/tasks often lead to questions of possible bias and reproducibility of the findings (Hao, Liu, von Davier & Kyllonen, in press). The goal of this workshop is to promote consensus on "standardized" practices for large-scale studies of computer-supported collaboration.

Large-scale collaborative activities require non-trivial technological infrastructure. Educational Testing Service (ETS) has made a major investment in developing a web-based platform to support collaborative learning and assessment (ETS platform for collaborative assessment and learning, EPCAL, Hao, Liu, von Davier, & Lederer, 2016). Different from most tools (such as Skype) that are designed to enable the collaboration, the EPCAL was designed to both enable the collaboration itself and facilitate the study of collaboration with additional team and task management systems. This platform allows multimodal communication, template-based task uploading, and customizable real-time facilitation/intervention. Most importantly, it is integrated with a powerful data analytics support from ETS's glassPy data analytics solution (Hao, Smith, Mislevy, von Davier, & Bauer, 2016). All these features make it an ideal environment to develop computer-supported collaborative research and assessment prototypes at large-scale.

In this workshop, we introduce the EPCAL platform to participants via a set of hands-on collaborative learning/assessment activities. Participants will team up in dyads or triads on the EPCAL platform to complete these tasks collaboratively. We will facilitate discussions on common challenges and solutions regarding designing collaborative learning and assessment environments and how the EPCAL platform can be used to support various needs of such designs. The planned activities includes the following:

- An overview of CSCL and the challenges
- Introduction of the EPCAL platform with live demo
- Selecting tasks/items from participants and deploy them to the EPCAL platform.
- Participants will team up into dyads or triads to complete tasks hosted on the EPCAL.
- Demo of real-time intelligent facilitation.
- Demo of collaboration process data analytics and visualization.
- Collaborative discussions and feedback via the EPCAL platform.

We encourage participants to bring in their own tasks/activities for this workshop, please visit our workshop website for more details about our currently supported task types. We will discuss how participants can use the EPCAL platform for their future research studies on collaborative learning and assessment and how the EPCAL platform may help to scale up their research work. In the discussion and feedback portion of the workshop, we welcome suggestions and comments for further improvements of the EPCAL platform.

Expected outcomes

The findings based on this workshop will be drafted into a white paper. Participants are welcome to contribute to the white paper to be listed as co-authors. This white paper will focus on practical implementation of computer-supported collaboration at large scale.

Endnotes

(1) See the workshop website at: https://sites.google.com/site/epcalcscl2017/

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Establishing a Foundation for Collaborative Process Evaluation and Adaptive Support in CSCL

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Abstract: To help make progress in understanding and designing for CSCL, it is important to have common data sets and tools to serve as a boundary object for discussion. For this workshop, we will organize groups for interactive work sessions based on prominent adaptive support themes, with concrete examples of collaborative learning based on pre-workshop preparation and coordination. Our aim is to examine trade-offs associated with analysis approaches at multiple levels of scale, from the individual, to the small group, to massive online settings. In the workshop, we will focus on applying what we know about manual coding to inform designs and implications for learning analytics and adaptive scaffolding.

Previous experience of organizers

The organizers have previously conducted and participated in a series of NSF-funded workshops on CSCL and adaptive support. In addition: Cynthia D'Angelo ran a workshop on cyberlearning themes at EC-TEL last year; Cindy Hmelo-Silver has been chair of ICLS and CSCL workshops, the doctoral consortium, and early career workshops; Alyssa Wise and Bodong Chen ran a series of temporality workshops at ICLS 2010, LAK2015 and LAK2016; Bodong Chen has chaired the doctoral consortium at LAK; Marcela Borge has chaired the Mid-Career workshop at ICLS and is currently a program chair for CSCL 2017, and Alyssa Wise has been chair of both workshops and the doctoral consortium at LAK.

Intended audience

The intended audience for this workshop is an interdisciplinary group of researchers that analyze social interactions in a variety of contexts. Our aim is to examine trade-offs associated with analysis approaches at multiple levels of scale, from the individual, to the small group, to massive online settings. As such, we encourage participation from those with technical interests in manual coding of communication, interaction analysis, learning analytics, intelligent systems, and adaptive support broadly conceived.

Description of the event

To help make progress in understanding and designing for CSCL, it is important to have common data sets and tools to serve as a boundary object for discussion. We will organize tables for interactive work sessions based on prominent adaptive support themes, with concrete examples of collaborative learning based on pre-workshop preparation and coordination. Some candidate themes might include:

1. Visualisation techniques for CSCL data
2. Coding schemes for different levels of analysis
3. Text mining approaches
4. Opportunities and challenges of temporal analysis of CSCL
5. Using data to provide instructional support

The half-day workshop will start with two 45 minute rounds of mini-tutorial knowledge exchanges surrounding each theme, with both experts and novices for each group so that all participants have opportunities to be teachers and learners. Each group will have a member of organizing group to facilitate the exchanges and raise key issues. Following these topic specialty discussions, we will create jigsaw groups that will allow cross talk grounded in the context of datasets that have been pre-coded from multiple perspectives. The final hour will leave time for reports from the jigsaw groups and whole group discussion.

Theoretical background and relevance to field and conference

Iterative classroom research and design of conversational agents to support a particular model of collaborative discourse has demonstrated both the possibilities and the challenges in implementing such adaptive support.

Howley, Mayfield, & Rosé (2013) have described approaches using machine learning that get at some of the complexity of collaborative discourse. They note, however, that these efforts often start with hand coding of data that eventually successfully enables automated coding of transactivity features and negotiation from online discussions. However, to get at the complexity of discourse, these techniques may have to sacrifice generalizability as most models of collaboration that underlie automated coding are suited to specific contexts (Mu et al., 2012).

Within the collaborative learning literature itself, there are several conceptual models of productive collaboration (see Hmelo-Silver, Chinn, Chan, & O'Donnell, 2013). Examples of such models include productive disciplinary engagement (Engle & Conant, 2002), Knowledge Building (Chan, 2013; Scardamalia & Bereiter, 2014), and group cognition (Stahl, 2013). There are also multiple designs for the development of collaborative learning environments such as problem-based learning, scripted collaboration, and group investigation (Hmelo-Silver & Chinn, 2016). An emerging and promising area of exploration in CSCL is the use of data collected on collaborative processes to inform ongoing collaboration in the moment or for future discussions the collaboration while it is still in progress (Borge, Ong Shiou, & Rosé, 2015; Wise et al, 2015). Ideally such feedback should be grounded in a model of collaborative learning and sensitive to the relevant particularities of the context in which the collaboration takes place (Suthers et al., 2015).

One key challenge for this workshop is to understand what aspects of collaboration may be general across many different types of settings, what aspects are particular as a function of age, context, discipline, collaboration modality and to better understand these contingent factors as part of constructing a model of collaborative learning. This is particularly challenging because although learning events are happening all the time, learning is a varied phenomena that is highly contextual.

Thus in the workshop proposed here, we will focus on applying what we know about manual coding to inform designs and implications for learning analytics and adaptive scaffolding. One of the goals of this workshop is to synthesize what has been learned by the participants with appropriate computational and research expertise to generate ideas for testing models and generating initial design considerations for adaptive support.

Expected outcomes and contributions

Expected outcomes of the workshop include compiling shared data sets and coding constructs for participants to think together with, networking and knowledge exchange both within and across expertise groups (e.g., qualitative discourse coding and automatic text analysis), improved strategies for and research questions about implementing adaptive support in CSCL, and an improved understanding of the challenges of doing this kind of work.

The data sets themselves will be an important contribution to the participants and possibly to the field at large. Each of the sample data sets will be coded by multiple experienced researchers prior to the workshop with different coding schemes and some preliminary analysis will be done ahead of time as well. These artifacts will help the participants think about their own data collection and analysis strategies.

The data sets have been chosen to represent different aspects of CSCL. Data Set 1 includes middle school students working face-to-face in groups of three, with a shared computer screen that shows their short problems to solve. While there is audio associated with this data set, a transcribed version will be available for the researchers to code. Data Set 2 includes text and clickstream data from the online asynchronous discussions of undergraduate students in groups of three to six solving authentic real-world business challenges in preparation for a joint in-class presentation. Data Set 3 includes synchronous chat-based text of an online discussion about course content for 13 teams, in five sessions across a ten week period. The dataset also includes individual reflections on the quality of chat session and team sensemaking about discussion quality at each time point.

Each of the data sets will be coded with multiple coding schemes. Some will be coding schemes that were initially developed to be used with one of those particular data sets, while others are meant to be used more broadly. This will allow the group to discuss the relative strengths and weaknesses of applying each coding scheme to each data set and explore the ways in which the coding schemes would lead to different analyses and/or findings with respect to the data. This will also allow for the exploration of different ways to represent both the data and the annotations/coding results and any analysis.

Participation requirements

Interest in CSCL, models of collaboration and adaptive support; willingness to engage in pre-workshop preparation activities that will involve coding two 2-3 page datasets (using one of the available coding schemes); looking to share expertise as well as learn about different aspects of analysis and support.

Relationship to similar events conducted in the past

Although not part of ICLS or CSCL, as part of an NSF Building Community and Capacity EAGER grant, a series of workshops were held in 2016 to discuss the challenges and best practices for collecting meaningful collaboration-related data that lends itself to learning analytics in both face-to-face and online settings.

Participation solicitation

Participants will be solicited via ISLS, SoLAR, and AERA SIG ATL/LS listserves as well as via social media. A draft of the call for participation is below.

Call for Participation Workshop on "Establishing a Foundation for Collaborative Process Evaluation and Adaptive Support in CSCL"

Do you have questions about how collaborative learning data can be used as input to instructional decision-making or adaptive support? About how models of collaboration can be used to decide what data is important and technically tractable? The goal of this half-day workshop is to provide opportunities for interactive knowledge sharing and discussions on these issues. Participants will be asked to code two short datasets prior to the workshop in preparation using either their own coding approach or select from a collection that will be provided by the conference organizers. These will then be used as a context to discuss issues central to the workshop topic. We will begin with several tables that include people interested in sharing knowledge or learning about a particular topic. A preliminary set of topics for discussion includes:

1. Visualisation techniques for CSCL data
2. Coding schemes for different levels of analysis
3. Text mining approaches
4. Opportunities and challenges of temporal analysis of CSCL
5. Using data to provide instructional support

Two rounds of discussions will provide opportunity for both sharing and learning within and across groups. We will then provide opportunities for whole group discussion. If you are interested, please fill out the application form at https://cpeas-cscl.github.io to indicate your interest, and which topics you are able to share knowledge about and what topics you would be interested in learning more about (as well as to suggest additional topics).

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Mobile Computing in CSCL: A Hands-On Tutorial on the ARIS Game Design Platform

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Abstract
In this session, participants will engage in a hands-on, tool-focused tutorial to gain tangible experience using ARIS (arisgames.org) as a CSCL tool to teach computational thinking. ARIS is an augmented reality and interactive storytelling platform with which non-programmers can design and develop their own location-based, interactive games or stories (Dikkers, Martin, & Coulter, 2011; Holden, Dikkers, Martin, & Litts, 2015). In contrast to the block-base and text-based platforms currently available, ARIS adopts an accessible narrative-based metaphor for programming, which opens up opportunities for situated and culturally relevant computing. During part one of the session, we will guide participants through an introductory tutorial of ARIS including first-hand experience with the collaborative design process ARIS supports. In the part two, participants will self-select into group-generated themes (e.g., history, english, folklore, games, field research, etc.) and design prototype implementations of ARIS for their particular contexts as well as identify what sorts of design and computational thinking skills ARIS supports within that context. We seek to equip participants with the knowledge and skills to integrate and implement ARIS in their particular learning environments with a particular focus on new ways to obtain computational thinking skills.

Facilitators' backgrounds
Our team brings a diverse set of skills and experiences with ARIS. **Dr. Breanne Litts** is an assistant professor in Instructional Technology & Learning Sciences (ITLS) department at Utah State University. She has worked on the design and development of ARIS for roughly seven years, and co-founded the Mobile Learning Incubator (now the Field Day Lab: https://fielddaylab.org/). Dr. Litts examines how youth learn design and computational thinking skills through building on the platform. **Stephanie Benson** is an ITLS graduate student, who examines uses of mobile technologies for outdoor education and has explored implementations of ARIS for environmental education. **Whitney Lewis** is an ITLS graduate student, who investigates how to leverage mobile technologies to support interactions in library spaces. **Chase Mortensen** is a computer science undergraduate, who not only builds his own mobile devices, but also supports youth in building and programming their own. Collectively, our team has conducted tutorials and workshops in a variety of settings for myriad audiences and purposes.

Introduction
Our proposed tutorial will have two parts: (1) An introductory tutorial of the ARIS platform and (2) A hands-on tutorial exploring collaborative implementations of ARIS for computational thinking across disciplines. ARIS (Holden, Gagnon, Litts, & Smith, 2013) is an augmented reality and interactive storytelling platform with which non-programmers can design and develop their own location-based, interactive games or stories. In contrast to the block-base and text-based platforms currently available, ARIS adopts an accessible narrative-based metaphor for programming. Hence, one of the key affordances of ARIS is supporting computational thinking skills in the social sciences in an authentic way. For example, history students might use primary source documents to design a location-based mobile game through which players learn about the signing of the Declaration of Independence and interact with historical characters (e.g., John Hancock) all while standing in front of Independence Hall. As part of the design process, students work collaboratively to identify game ideas, conduct primary and secondary research, learn about and apply different design and computational thinking skills and practices, and share their final products with classmates and others in the community. During the first part of the session, we will guide participants through a rapid version of this design process.

In the second part of the session, participants will self-select into group-generated themes (e.g., history, english, folklore, games, field research, etc.) and design prototype implementations of ARIS for their particular contexts as well as identify what sorts of design and computational thinking skills ARIS supports within that context. By following up the tool-focused tutorial with a hands-on activity, we will be providing participants with tangible experience using ARIS as a CSCL tool to teach computational thinking. We seek to equip participants with the knowledge and skills to integrate and implement ARIS in their particular learning environments with a particular focus on new ways to obtain computational thinking skills.

Relevance to the field and conference theme

The CSCL community is generally concerned with questions around how technology supports collaborative meaning-making across a range of settings and disciplines (Stahl et al., 2006). Implementations of ARIS inform these CSCL investigations on two levels: (1) engaging participants in a collaborative design process and (2) promoting meaning-making with a community. The ARIS platform supports collaborative design trajectories, where groups work together to make their own interdisciplinary, multimodal design project, and community production through a robust online user community (Holden, Gagnon, Litts, & Smith, 2013; Gagnon, Vang, & Litts, 2015). Moreover, ARIS is rooted in place-based learning, which highlights the importance of "building long-term relationships with familiar, everyday places" (Gruenewald, 2003). Hence, at the project-level the games and narratives that users design engage with the community in unique ways to promote critical engagement with community meaning-making. Cases include games that promote citizen science through critical interaction with environment issues as well as civic participation in current or historical issues (Dikkers, Martin, & Coulter, 2011; Holden, Dikkers, Martin, & Litts, 2015). ARIS offers non-programmers a sandbox-like platform on which to build these collaborative experiences, which makes it accessible across audiences and disciplines.

As such, this session complements the conference theme of *making a difference* by *prioritizing equity and access in CSCL*. In addition to the collaborative and community-focused nature of ARIS, its narrative-based format, which is unique compared to other block- and text-based programming platforms that exist, promotes collaborative meaning-making through story, especially focused around issues of citizenship and history. Furthermore, learners from all backgrounds are able to access and use ARIS as it is an open-sourced, free tool. Thus, ARIS is an on-ramp to computational thinking for social sciences and it encourages culturally responsive teaching by giving diverse learners a platform where they can manifest ideas that highlight, challenge, or support community topics, which can then be explored by other learners.

Expected outcomes/contributions

Our proposed session will contribute both a new tool and approach to support CSCL as well as a new perspective toward computational thinking. We hope this session will draw a wide, diverse audience, who will leave equipped with the tools to integrate and implement ARIS in their respective contexts. Furthermore, one major contribution of the session will be broadening our ideas and applications of computational thinking to include new spaces and disciplines such as social sciences.

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Reflections and Discussions About NAPLeS Learning Resources for the Learning Sciences

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Abstract: Based on the great amount of achievement the NAPLeS initiative has reached so far (more than 50 webinars and more than 100 video recordings with experts in the field of Learning Sciences, more than 25 Syllabi collected from the NAPLeS member programs, etc.) the goal of this workshop is to bring together Learning Scientists (who are or will be teaching Learning Sciences at university) and NAPLeS liaisons that are the contact persons between the NAPLeS initiative. Participants are expected to reflect upon the already existing learning resources for the Learning Sciences, to discuss new ways to present theses resources at the ISLS webpage, and to plan and create new learning resources.

Theme and goals

The NAPLeS initiative has created a great amount of learning resources for the Learning Sciences. Within this initiative more than 50 webinars with experts in the Learning Sciences were conducted on an international level. The webinars were recorded and the recordings were made available on the NAPLeS interim webpages. Also, more than 100 videos with experts in the Learning Sciences were recorded, more than 25 Syllabi from the member programs were collected, and they were uploaded to the NAPLeS interim webpages. The learning resources at the interim webpages of the NAPLeS initiative are very popular all over the world with millions of clicks and an increasing amount of links. Now, since the new ISLS webpage has been launched and with the possibilities that may arise from the technology behind that webpage, it seems to be the right point in time to reflect upon the learning resources that are already there, how they might be presented differently at the new webpage and what are further learning resources that could be collected or created.

Therefore, the goal of the workshop is to bring together Learning Scientists and NAPLeS liaisons at different levels of expertise to engage in the reflection about the NAPLeS learning resources that already exist and the discussion about what kinds of learning resources might be additionally created and offered in the NAPLeS section on the recently launched ISLS webpage. The participating Learning Scientists may not only be on different levels of expertise but also from different fields. This means that we are expecting experts in the field of computer science, educational science, teaching and so on. The collaboration of these experts during the workshop should lead to rich ideas for resources that can be offered on the NAPLeS webpages. Since this is the first NAPLeS workshop at a CSCL conference a particular focus of this workshop will be on collaborative learning experiences that can be offered at the new NAPLeS webpages. The expertise of the participants about effective implementation of computer-supported collaborative learning should lead to cutting edge ideas how to create a computer-supported collaborative learning environment for Learning Sciences content. We will try to implement the ideas and sketches of Learning Sciences resources on the ISLS webpage and make them accessible to all ISLS and NAPLeS members.

Theoretical background and relevance to field and conference

There is a great number of academic programs, be it explicitly Learning Sciences programs or programs from adjacent fields like Educational Psychology, spread all over the world teaching the basics of Learning Sciences (https://en.wikipedia.org/wiki/Learning_sciences; http://isls-naples.psy.lmu.de/syllabi/index.html). When searching through the syllabi of these academic programs it becomes clear that the programs, despite of many similarities, also differ in what they define as being core to the Learning Sciences and what should be taught in a Learning Sciences introductory course.

In order to get a clear understanding of what should be common knowledge and skills of Learning Scientists, various viewpoints have to be taken into account. One of these is a content wise viewpoint, for example taken by the "Handbook of the Learning Sciences" that has already been published in its second edition. It introduces what it deems the most important topics for a Learning Scientist subsumed under the subheadings "Foundation", "Methodologies", "Practice that foster Effective Learning", "Learning together", and "Moving the Learning Sciences into the Classroom" (Sawyer, 2006, 2014). From a political viewpoint the

International Society of the Learning Sciences has been founded, framing the Learning Sciences with their vision statement (Pea, 2009). Alternatively, a sociological point of view would stress the importance of introducing and connecting young researchers to the already experienced Learning Scientists in order to learn the core aspects of Learning Sciences. Enculturating young and more experienced Learning Scientists into the community is one of the aims of the educational board of the International Society of the Learning Sciences. For this the educational board regularly conducts doctoral consortia and early career workshops. Furthermore, the NAPLeS initiative was founded to connect international Master's and PhD programs in the Learning Sciences. The NAPLeS initiative also implicitly created a list of core topics to the Learning Sciences, by producing a large amount of video resources with influential Learning Scientists speaking about their research topics, which are core to the Learning Sciences. The video resources include short 5- and 15-minutes introductions to the topics as well as interviews and the recordings of 90-minutes live-webinars. All videos are classified in one out of four categories, namely "How people learn", "Supporting learning", "Methodologies for the Learning Sciences", and "Computer-Supported Collaborative Learning".

Overall, many sources of information are available that can be used to extract the topics that are core to the Learning Sciences and should be included in a Learning Sciences core curriculum or in the syllabus of a Learning Sciences introductory course. Yet, till now no one has undertaken the effort to plan and produce a general introductory course that takes all those perspectives into account (handbooks, experienced learning scientists, etc.) and is freely available for the use of any lecturer who wants to teach basic knowledge and skills in the Learning Sciences.

Expected outcomes and contributions

We expect that the participating Learning Scientists and NAPLeS liaisons will contribute to the reflection about the NAPLeS learning resources that already exist and the discussion and creation of new learning resources (that could also be a new combination of already existing resources) for the NAPLeS initiative with their multiple viewpoints on what might constitute the Learning Sciences. The outcome will be retrospection on the achievements of the NAPLeS initiative so far and also a broad portfolio of sketches for different Learning Sciences resources that can be part of the new ISLS webpage. Also, we expect to form one or more task forces with Learning Scientists committing to further improve and finalize the learning resources. In particular, we are expecting that CSCL experts will work on the development of cutting edge computer-supported collaborative learning experiences for Learning Sciences content. In this way we will not only implement computer-supported collaborative learning to be used by Learning Sciences newcomers, but we will also create blueprints of collaborative learning environments that may be transferred to other domains.

The fit of the workshop and the conference theme

The CSCL 2017 conference theme "Making a Difference – Prioritizing Equity and Access in CSCL" fits very well to the proposed workshop. One part of the discussions during the workshop will also be about how open the learning resources can be presented. The current policy of NAPLeS is to make the resources available to everyone who is interested in Learning about Learning Sciences. We hope that the discussions during the workshop will lead to the support of this policy that gives everyone equal access to the resources without discrimination.

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Digitally-Mediated Design Thinking in CSCL Environments

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Abstract: This is a generative workshop in which participants will collaboratively design solutions to the wicked problem of digitally mediated design thinking in computer-supported collaborative learning environments. Participants will engage in the design thinking process to design innovative solutions. Data collected—including reflection notes at six stages, videos and photos of group presentations, and interviews with participants after the workshop—will be collaboratively analyzed and written up by all workshop participants, to be submitted for publication.

Facilitators' backgrounds

Jonan Phillip Donaldson is a Ph.D. student at Drexel University. He has been an educator for two decades, and has been particularly interested in developing computer-supported collaborative learning environments grounded in the principles of constructionist learning.

Amanda Barany is a Ph.D. student at Drexel University in the Educational Leadership and Learning Technologies program. Her research interests focus on the development and implementation of games as learning tools to support engagement, interest, valuing, and identity development around STEM careers.

Brian K. Smith is a professor in Drexel University's School of Education.

Defining the problem

Design thinking has been described in the literature as a) the cognitive strategies expert designers bring to their practice (Cross, 2006), b) a design process (Brown, 2008), and c) a mix of cognitive strategies and processes (Johansson-Sköldberg, Woodilla, & Çetinkaya, 2013). Design thinking has also been proposed as a framework for development of 21st-century skills (Razzouk & Shute, 2012; Luka, 2014; Long, 2012; Watson, 2015; Koh et al, 2015). A growing body of research is forming around the use of design thinking in learning environments. The application of design thinking in learning contexts has tended toward the use of design thinking process models. For instance, researchers at Stanford University have used design thinking process models in middle school geography classes (Carroll et al, 2010) and afterschool STEM programs (Carroll, 2014). In Turkey, Gözen (2016) studied creative problem-solving skill development of pre-school and primary school students through the use of the design thinking process. Benson & Dresdow (2015) used the design thinking process to develop management decision-making skills of undergraduate university students. Vanada (2014) investigated middle school art students' development of creative confidence and balanced thinking through the use of the design thinking process. Norris (2014) used the design thinking process as a means for minority high school students to engage in identity exploration. Svihla & Reeve (2016) investigated the role of design thinking in facilitating development of high school students' problem-framing skills.

There are a variety of design thinking process models (Kimbell, 2011), but at the heart of each is a stage which involves both divergent thinking (idea generation) and convergent thinking (pattern recognition, synthesis, and integration of ideas)—a stage commonly known as ideation (Brown, 2008; IDEO, 2012; Mickahail, 2015). The ideation stage is typically characterized as a collaborative process (Carroll et al, 2010). The process typically starts by having participants silently write down on sticky notes as many potential solutions as they can imagine. They then place the sticky notes randomly on a wall. Participants gather at the wall and silently move sticky notes around, resulting in clusters of ideas. Finally, participants discuss the ideas and patterns, which they synthesize and integrate. Finally, they agree upon one idea or synthesis of ideas to develop further in the prototyping stage of the design thinking process.

The typical ideation process involves several features, which are uniquely dependent upon the physical environment. First, the use of sticky notes allows for a large number of ideas to be recorded as distinct units. Second, the placement of sticky notes on the wall allows participants to take all the ideas in at a glance, "zoom in" to explore specific ideas, and then step back to consider the ideas in relation to each other. Finally, the ability to move sticky notes around on the wall allows for a particular operationalization of convergent thinking, in that pattern recognition and pattern creation can occur simultaneously.

The unique affordances of sticky notes on walls in the ideation stage of the design thinking process have proven difficult to translate directly into digitally mediated learning environments such as online classes. Learners often use laptops and tablets when engaging in online learning, and even if they are using desktops, the screen size and resolution limit participants' capacity to see several hundred virtual sticky notes on one screen. If they had to zoom in to view a particular idea, they might lose the larger context of the wall and find it difficult to decide where to move that idea in proximal relation to other ideas on the wall. Furthermore, the collaborative nature of the process of moving sticky notes around on the wall is crucial; If participants were to take turns moving sticky notes around, for example, the organic nature of the emergent patterns would be compromised.

Hollan & Stornetta (1992) used the example of video communications technology to demonstrate the principle that technological innovations should not be based on attempts to replicate the affordances of physical spaces in digital spaces. Rather than trying to improve the quality of video communications technology toward achieving the experience of "being there," we should innovate around the particular affordances of digital technologies to create experiences/abilities not possible in physical spaces alone—to go "beyond being there" (p. 120). The popularity and widespread use of the design thinking process attests to its value. However, attempts to replicate in digital spaces the way design thinking processes play out in physical spaces have illustrated these challenges.

Operationalizing the ideation stage of the design thinking process in digitally mediated computer-supported collaborative learning environments can be viewed as a wicked problem (Rittel & Webber, 1973). To this end, this workshop will engage a group of innovative thinkers in a design thinking project aimed at framing and developing creative solutions that go beyond simply replicating the physical space operationalization of ideation.

Format and schedule

Participants in this full-day workshop will use the design thinking process to develop solutions for ideation strategies in digitally mediated environments. The process used here is based on the Stanford d.school (Mickahail, 2015) and IDEO (2012) process models (see Table 1). While digital reconceptualizations may prove necessary across all stages of the design thinking process, the problem and solutions developed in the workshop will focus on only the ideation stage of this model. The process used by workshop participants will include all stages of the design thinking model - framing, ideation, prototyping, and preliminary deploying - but due to time constraints, full-scale deploying and iteration will not be possible.

Table 1: The design thinking process model

<table>
<tr><td>Workshop Design Thinking Model</td><td colspan="2">Framing</td><td>Ideation</td><td>Prototyping</td><td colspan="2">Deploying</td><td>Iteration</td></tr>
<tr><td>Stanford d.school Model (Mickahail, 2015)</td><td>Empathize</td><td>Define</td><td>Ideate</td><td>Prototype</td><td colspan="3">Test</td></tr>
<tr><td>IDEO Model (IDEO, 2012)</td><td>Discovery</td><td>Interpretation</td><td>Ideation</td><td colspan="2">Experimentation</td><td colspan="2">Evolution</td></tr>
</table>

Table 2 describes the schedule, activities, design thinking stages, and types of data collected in and following the workshop. See the detailed schedule for more information.

Table 2: Schedule, activities, design thinking stages, and data

Time	**Activity**	**Design Thinking Stage**
~30 min	Presentation situating the problem	
~45 min	Group framing (re-defining) the problem	Framing
~20 min	Silent brainstorming on sticky notes, randomly place on wall	Ideation
~20 min	Silent re-organizing of sticky notes on the wall	
~30 min	Discussion (at wall): synthesis, integration, selection	
~60 min	Prototyping	Prototyping
Lunch Break		

Time	Activity	Design Thinking Stage
~120 min	Prototyping	Prototyping
~60 min	Group presentations	Preliminary Deploying
~15 min	Discussion	
~20 min	Planning next steps: Data analysis and publishing	
Post-WS	Selected interviews of participants	
Post-WS	Data preparation and dissemination among WS participants. Collaborative data analysis, write-up, and editing. Submission for publishing.	

Workshop goals and outcomes

The purpose of this workshop is to engage participants in a generative process resulting in innovative solutions to the problem of operationalizing the ideation stage of the design thinking process in digitally-mediated collaborative learning environments. The end product of this workshop will include a number of potential solutions, as well as one or more publications collaboratively authored by the participants in subsequent months.

Relevance to the conference theme

Because the design thinking strategies for ideation (currently used in both design firms such as IDEO (2012) and in educational settings as described in the introduction) are dependent upon physical interaction with sticky notes on walls or windows, and upon physically co-located synchronous collaborative manipulation, these strategies are not readily available to learners who are limited to digitally-mediated learning environments such as online classes. The solutions and research findings produced by workshop participants have the potential to increase access to learning through design thinking processes.

Situating the workshop

Intended audience

This workshop is intended for participants who wish to collaboratively construct knowledge. It will be particularly attractive to participants with interests in design thinking, new strategies for the design of computer-supported collaborative learning environments, and leveraging the affordances of digitally mediated learning.

Participation requirements

Participants must be willing to continue workshop activities online after the workshop for several months, including data analysis and writing up research findings for publication. Participants must also allow co-participants to conduct analyses and develop publication writings based on the data they produced during workshop activities.

Facilities and equipment required

One conference room is needed, and should include a large amount of wall space.

Minimal and maximal number of participants

The nature of the workshop activities requires a minimum of 12 participants and a maximum of 20 participants.

Participant solicitation

Here is the call for participation script.: https://docs.google.com/document/d/1008OLWOxoBuSiMXrv-ToFIQEwoSdOghO7b6Ug2BFeQY/edit?usp=sharing

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Early Career Workshop

CSCL 2017 Early Career Workshop

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Summary

The *Early-Career Workshop* provides opportunities for researchers working in CSCL and in the Learning Sciences early in their careers to discuss their own research, to discuss post-doc and early-career challenges with peers and senior mentors, and to initiate international networks related to their research topics. There will be online interaction to prepare for the conference workshop where participants will identify common interests with respect to research and common challenges with respect to this early phase in their academic career. During the workshop that takes place over 1.5 days, participants will present their research and get feedback, talk to different mentors in small groups, and discuss possible new international research networks with their peers. In addition, a "meeting with the journal editors" session will be organized. The main contents of the workshop include: Research funding opportunities for post-docs and early career researchers; how to develop a research agenda, and/or consider their own career development; publishing–where and how much, promotion; how to mentor and supervise graduate students; new research methods; and possibilities for building international research networks? The workshop will also have a focus on the specifics of the CSCL community and on the challenges and opportunities that exist in our community (e.g., interdisciplinarity, gaps between different methodological approaches). The early career workshop is designed for post-doc and early career researchers starting with those who have just finalized their doctoral thesis to those having 5 years of experience after receiving the doctorate with research interests in CSCL and the Learning Sciences.

Table 1: Early Career Workshop Participants at CSCL 2017 Philadelphia.

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Subgoal Learning in Online STEM Instruction

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Summary of recent work

My research aims to improve problem solving performance of STEM students learning in environments in which they do not necessarily have instructors to help them resolve problem solving impasses, such as online learning. As the number of students pursuing bachelor's and advanced degrees increases, so does the ratio of students to instructors and the number of online courses (Bok, 2015). These factors make direct interaction between students and instructions increasingly limited and self-regulated learning increasingly valuable (Bok, 2015). To help students be more independent from instructors, at least in some learning environments, support from learning scientists is needed to understand differences between self-regulated and instructor-regulated learning and how to support self-regulation. My work examines these issues by integrating subgoal learning and self-explanation.

The common thread in my main line of research is subgoal learning. Subgoal learning has improved problem solving performance in STEM domains, including computer programming, chemistry, and statistics, by teaching learners the subgoals, or functional pieces, of problem solving procedures (e.g., Margulieux, Catrambone, & Guzdial, 2016; Margulieux & Catrambone, 2016). When students are taught the subgoals of a procedure, they retain information and solve novel problems better (e.g., Margulieux et al., 2016). However, instructors, as experts in the field with tacit knowledge of problem solving procedures, often do not realize that students need procedures broken down into subgoals (Catrambone, 1998). This oversight does not matter as much in brick-and-mortar classrooms in which the students can ask the instructor questions about the procedure (and keep asking until they understand the answer) as it does in online learning in which students often wait several hours to get an answer from an instructor and, unless they asked the right question, might still not understand.

Until recently, subgoals have been taught in independent learning environments (i.e., without an instructor) by explicitly telling learners the subgoals of a problem, a passive method of learning. Passive learning is largely regarded as less effective than more engaging methods of learning, like self-explanation (Chi, 2009). My research explores the efficacy of teaching learners subgoals through self-explanation. Self-explanation is a process in which learners use what they already know, new information that they are given, and logic to explain to themselves how a problem was solved. Learners who self-explain better integrate new and old knowledge, improving their retention and transfer of problem solving procedures (Wylie & Chi, 2014). Few students are intrinsically motivated to self-explain, but they can be externally prompted and reap the same benefits (Wylie & Chi, 2014). To prompt self-explanation and to teach subgoals, my research explores methods of guiding students to construct their own descriptions of the subgoals of a procedure.

My most recent project up to this point has explored 16 various types of guidance to support students in learning the subgoals of computer programming procedures. As expected, the results showed that students who learned through self-explanation performed better than those who learned passively. In other words, those that explained to themselves why problem solving steps were taken performed better than those who were told why problem solving steps were taken. Among students who learned through self-explanation, I gave some more guidance while giving others less, and I gave some feedback but not others. In some cases these supports improved learning. Unexpectedly, students who received both guidance and feedback performed worse than those who received only guidance or feedback. It is unclear why receiving two types of support caused students to perform worse than receiving one type of support. My next steps will be exploring this interaction to understand factors that inform development of online learning systems that can offer multiple types of support without inadvertently hindering student performance.

Theoretical frameworks

Besides the subgoal learning framework, Interactive, Constructive, Active, and Passive (ICAP) framework, and feedback, I try to account for variables of interest from multiple fields to best explain the results of my research. For example, from cognitive psychology, I measure working memory capacity and cognitive load; from educational theory, I measure perception of understanding, confidence, prior knowledge, and demographic data to explore individual differences; and from computing education, I measure prior math experience and comfort with computers. I am interested in learning about new frameworks and variables from areas that are outside of my expertise, that I can incorporate into my research to better explain the results. Most of my work is conducted in computing education, but I have conducted work in other STEM domains and am interested in continuing that work, especially in engineering education.

Methods

I earned my degree in May 2016 in engineering psychology, the study of how people interact with technology. I have a strong background in experimental and quantitative methods, and pretty limited training in qualitative methods. The focus of my research throughout my training was on educational issues, including educational technology. I have developed my own instructional materials for my research, and I have a lot of experience with task analysis and a medium level of experience with instructional design.

All of my research has used experimental methods, mostly in a laboratory environment, and most of the data were quantitatively analyzed. All of the individual differences (e.g., demographics, working memory capacity, and cognitive load experienced) are scored and analyzed using quantitative methods. I measure learning and problem solving performance by asking participants to solve novel problems, which are scored and analyzed quantitatively. I also use some measurements to try to measure how participants think through the problem solving process or how well they conceptually understand the process, but these measures are mostly scored into similar bins and reported as the number of participants in each group that was categorized into each bin. In my analyses, I always discuss the results for experimental groups as a whole, never for individual learners within those groups.

After graduating, I joined the faculty at a college of education, and though my department values my quantitative methods and analyses, I would like to incorporate some qualitative methods into my work and discuss learning on more individualized level. I also want to learn more about qualitative methods because many of the doctoral students who I will be advising will be using qualitative methods.

Plans for future work

I want to continue to explore the theoretical underpinnings of my work, but I want to devote much more time to implementing my instructional interventions in authentic learning environments across longer periods of time. I work at a "very high research activity" university where external funding is increasingly expected and emphasis on learning sciences is also increasing, so those are also a factor in my plans.

1. One of my plans for future work is to continue with my most recent project to explore the interaction of different types of instructional support on learning. I have a few hypotheses about factors that affected the results that I did not measure or control, and I am planning a series of follow-up experiments to test these hypotheses. I am applying for an internal grant through my university to fund this work.
2. I have applied for NSF EHR Core Research grant to expand my research into engineering education. This project would implement subgoal learning into an intro engineering course, Statics. The team, which includes a psychologist, a learning scientist, and engineering professors, and I would develop instructional materials that could be used across all offerings of Statics at our university and, we hope, at other universities. This project is an example of the type of work I want to do that contributes to theory but also has applications to courses.
3. I have applied for NSF STEM + Computing Partnerships grant to expand my research into K-12 education. This project would use my subgoal learning method to teach STEM teachers basic computing principles and then help them to develop activities that they can do in their classrooms to use computing principles while teaching their subjects. We want to work with science and math teachers at a nearby school district that currently has a large population of students who are underrepresented in computing to offer them more opportunities to engage with computer science and broaden participation in computing.
4. Last, I have a couple small projects that all apply my subgoal learning method in new environments. I am working with a graduate research assistant to apply subgoal learning to an adaptive homework tool called ASSISTments to help high school math students practice quadratics. I am also working with a faculty member who has strong corporate training ties to apply subgoal learning to corporate training.

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Analysing Collaborative Problem-Solving From Students' Physical Interactions

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Abstract: Collaborative problem-solving (CPS) is a fundamental skill for success in modern societies, and part of the most common constructivist teaching approaches. However, its effective implementation and evaluation are challenging for educators. Current inquiries on the identification of the observable features and processes of CPS are progressing at a pace in digital learning environments. However, still, most learning and teaching occurs in physical environments. In my current research, I investigate differences in student behaviours when groups of students are solving problems collaboratively in face-to-face, practice-based learning (PBL) environments in high school and universities. My data is often based on students' hand position and head direction, which can be automated deploying existing learning analytics systems. Using nonverbal indexes of students' physical interactivity in PBL, I try to interpret the key parameters of CPS including synchrony, equality, individual accountability, and intra-individual variability. The ultimate aim of my research is to be able to continuously evaluate and support students' collaborative learning during their engagement with constructivist pedagogies.

Introduction

Collaborative problem-solving (CPS) is a fundamental skill for modern societies to function and it should be supported and practiced in Education systems across the globe. Perhaps, as the significance of CPS is clear to most educators, it is part of many common constructivist teaching approaches including problem-based learning, inquiry-based learning, project-based learning, and practice-based learning. It is common to see situations in which learners work in unison to solve a problem during these teaching approaches, and often that is why these constructivist teaching approaches are considered to have the potential to help foster the 21st-century skills we require of young people. For some decades now, there have been strong advocates of these teaching approaches in Education, arguing their merits in achieving high-tier learning objectives. However, existing evidence on the effectiveness of these methods to satisfy their learning outcomes is rare, and they have been harshly criticised by some researchers as not being effective pedagogical approaches (Kirschner, Sweller, & Clark, 2006).

According to Blikstein and Worsley (2016), this lack of evidence may stem from these pedagogical approaches' notoriously dynamic and laborious structures and commonly used standardised measurement method's lack of ability to detect impacts on students' skill development. However, the most recent developments in sensor technologies and learning analytics methodologies can help generate unique information about what happens to groups of students are engaged in constructivist pedagogies. The distinctions between groups can be used to continuously evaluate and support students during their engagement with constructivist pedagogies. In my research, I focus on CPS in practice-based learning activities and investigate the potential of multimodal learning analytics research to generate and present salient features of effective CPS behaviours of students in these open-ended, small group learning environments.

Theoretical framework

CPS is a complex process that requires implementation of multiple social and cognitive competencies. This makes its observation, to see whether the CPS is of quality or not, extremely challenging for educational researchers and practitioners. In the learning sciences literature, there have been certain mechanisms suggested through which collaboration and problem-solving may influence cognition and support deeper learning. They include students demonstrating an ability to:

1. articulate, clarify and explain their thinking;
2. re-structure, clarify and in the process strengthen their own under- standing and ideas to develop their awareness of what they know and what they do not know;
3. adjust their explanations when presenting their thinking, which requires that they can also estimate others understandings;

4. elaborate and internalise their new understanding as they process the ideas they hear about from others;
5. establishing and maintaining shared understanding; taking appropriate action to solve the problem; establishing and maintaining team organisation.

Looking at the suggested mechanisms from the learning sciences above, it becomes clear that all the mechanisms presented above require investigation of complex verbal interactions of students and most of them require quality judgments from the observers. Therefore, the evidence related to the existence of these mechanisms and their quality is hard to generate and implement at a scale. Although there is promising research on investigating students verbal input in digital learning environments, including chat boxes, verbal interactions with online agents and mobile tools that collect students written reflections on their CPS practices, such investigations are far from being straightforward. The investigation of complex CPS mechanisms through verbal indexes often require qualitative value judgments that are hard to validate, automate, and rely on. In my research I investigate students' nonverbal indexes of their behaviours including synchrony, equality of physical participation, intra-individual variability and individual accountability. I argue that some of the key constructs that constitute complex learning processes such as collaborative problem-solving can be interpreted with the use of students' nonverbal behaviours. These indexes of behaviours have the potential to reflect genuine observations of students intentions and ideas and can be automated with the help of using multimodal learning analytics systems.

Methods

In my current research, I use an analysis framework developed (Cukurova et al., 2016) based on the OECD's exhaustive work on CPS to create an independent variable of students' CPS competencies. I invite teachers and educators to categorise groups of students as high, medium, and low competence CPS groups using their expert opinion and the OECD based CPS framework. I, then, investigate how do behaviours of those groups who are categorized as high competence CPS group differ from Medium and Low competence groups in terms of machine observable nonverbal indexes of human behaviours such as synchrony, equality, individual accountability and intra-individual variability. In addition to these constructs, I compare high competence CPS groups' multimodal learning analytics data generated from their hand tracking, head direction, emotional feedback, and voice levels (Spikol et al., 2016).

Future work

The simple coding scheme of students' active, semi-active and passive positions, we created (Spikol, Cukurova, Ruffaldi, 2017) is a practical and valuable approach that can inform the design of automated analysis systems. It can be used to interpret the key components of CPS including students' participation, responsiveness, perseverance, awareness, etc. I can be automated and applied to a real classroom environment by using a learning analytics system that has the potential to detect the head directions and hand position of students (using fiducial marks for instance) such as the one we developed in a recent EU-funded research (www.pelars.eu). My future research will focus on attempts to expand the key constructs of CPS (and potentially other student skills) that can be interpreted through indexes of students' nonverbal behaviours. I will also work to automate this process of coding of nonverbal indexes of student interaction to be able to provide real-time feedback to students and teachers about their CPS patterns. These results would have significant implications both for the design and implementation of CPS activities in classrooms and they would increase the accuracy and timeliness of teacher interventions.

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Using Computer Models and Collaboration to Explore Energy Concepts

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Abstract: In order to encourage student exploration of energy concepts, I implemented an 8^{th} grade science and engineering unit entitled, "*Self-Propelled Vehicles"* using the Web-based Inquiry Science Environment. I use the knowledge integration framework to guide the design of the lesson and the assessment of student ideas (Linn & Eylon, 2011). During the unit, students interact with computer models; engage in collaborative discussions with their peers; and design, build, and test their own self-propelled vehicles.

Overview

As a postdoctoral scholar at the University of California, Berkeley, I have spent the last two years conducting research investigating ways to promote knowledge integration using computer models embedded in the Web-based Inquiry Science Environment (WISE). I focus on complex science topics such as potential energy, kinetic energy, and thermal energy, along with energy transformation and conservation. Specifically, I have led a partnership design process to create a unit that features collaboration and combines computer modeling with hands-on experimentation around the topic of self-propelled vehicles. My research concerns how best to guide collaborative investigation such that students gain coherent, robust understanding of energy concepts and science practices.

Theoretical framework

I designed the self-propelled vehicles unit following the knowledge integration (Linn & Eylon, 2011) framework. Knowledge integration builds on the diverse set of ideas students have from prior experience and from instruction to develop coherent views. For example, many students believe that by reducing the friction in a vehicle (e.g. between the axle and the body of the car), they can both increase the car's kinetic energy and the car's potential energy (potential energy is not affected). As students interact with novel material, they distinguish among alternative ideas and incorporate new ideas. I am testing and refining inquiry-based activities to identify ways to help students add and distinguish ideas and reflect on this process to create an effective explanation.

Computer models and collaboration during a science lesson

I formed a partnership with preservice and in-service teachers, technologists, and discipline experts to design a collaborative unit on self-propelled vehicles. The students collaborate to create a scooter that is powered by a rubber band, balloon, or other energy source. The unit focuses on potential, kinetic, and heat energy and has the goal of helping students understand forms of energy, graphs of energy, and conservation of energy while using engineering design practices.

I implemented a computer model to help students explore these science concepts. During the self-propelled vehicles unit, students made predictions about how a car's energy would transform as it traveled across a track. After making a prediction, students interacted with a computer model of a self-propelled car that was powered by inflating a balloon and then releasing the air from the balloon. As students inflated the balloon and altered other features of the car (e.g. mass, friction, wheel size), they observed graphs of distance vs. time and energy transformation. After exploring the computer model, students had the opportunity to use what they had learned to design, build, and test a physical model of a self-propelled vehicle.

To encourage student collaborators to consider tradeoffs of potential, kinetic, and heat energy, I worked with the science teacher to create a "consultant/client" activity. Students had already designed, built, and tested a self-propelled vehicle with their partner. Students recorded how far their car travelled. For the second round of testing, students were given a target that was the median distance of all of the pairs' distances. Therefore, half of the class' cars needed to travel a farther distance and half of the class' cars needed to travel a shorter distance. After exploring the computer simulation with parameters like mass, friction, and wheel size, students met in groups of four. Groups were assigned such that one pair's car had travelled a shorter distance than the target and the other pair's car had travelled beyond the target. Each pair took a turn being the "consultants" and the "clients". In this situation, each pair could provide useful information to the other partner pair based on their testing experience.

Videotapes of student groups are being analyzed to determine the advantages of the "consultant/client" activity for collaboration.

Methods

I use the knowledge integration framework to guide iterative refinement of the curriculum design and to assess the success of the self-propelled vehicles unit. I *elicited* the students' ideas through predictions, *added* to their ideas through open exploration of computer models, helped them to *distinguish* ideas as they evaluated their own original predictions and updated their ideas based on the new information they gathered, and encouraged students to *integrate* these ideas through final reports.

In addition to a learning framework, knowledge integration provides an overarching rubric for assessing student answers to open response questions (Liu, Lee, & Linn, 2011). Knowledge integration acknowledges the diverse set of ideas that students hold. Without penalizing for alternative ideas, the knowledge integration rubric focuses on student ideas and awards higher scores for linking two or more ideas together. Student responses are scored from 1-5. By including a wider range of possible values, and not using a simple binary score, we can better assess improvement as students move from non-responses (1; e.g. "I don't know"), alternative ideas (2) or single ideas (3) to more complex responses that link ideas together (4-5).

Using hierarchical linear modelling (HLM), I can assess the students' improvements in understanding after they interact with the WISE lesson. HLM allows me to use 2 and 3-level designs. Because students respond to multiple posttest questions, a random effect for student recognizes these responses both as unique data points and also as being nested within a student. Similarly, a random effect for the student pair can recognize that two students might perform more similarly to one another because they completed the unit together.

Future directions

As I move forward with my research, I intend to continue asking and answering questions around the benefits of technology and the role of collaboration in student learning. As I iteratively refine current graphing and modeling activities, I will also be looking for how to take advantage of the pairs or small groups the students are working in. Some activities that show promising results include highly structured collaborative discussions. These activities included sentence starters and specific topic guidance and helped students stay engaged throughout a 30-minute collaboration session. Other collaborations, such as assigning roles, have also provided a productive structure to collaborate while exploring computer models (Vitale, Applebaum, & Linn, CSCL 2017). I look forward to continuing to investigate questions around technology and collaboration in the future.

During the Early Career Workshop, I hope to have the opportunity to discuss future career options based on my interests in the benefits of computer models and collaborative learning. Additionally, I hope to gain valuable insights into CSCL through the mentoring experience. I am particularly interested in learning about what other researchers do to support collaboration in the dynamic classroom environment and what promising strategies other researchers have successfully used to encourage students to share their ideas while engaged with computer models. Specifically, I am interested in knowing how researchers keep track of different students' ideas and how they identify how collaboration with a partner may have changed or improved upon those ideas.

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Intercultural Computer Supported Collaborative Learning

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Research agenda and areas of interest

My area of research focuses on the nexus between learning, technology and culture. Given the close connections between culture and learning, today's learning environments in general and online learning environments in particular must be designed and implemented to meet the needs of learners with diverse cultural backgrounds. Specifically, I examine learning processes of knowledge co-creation through conversational/argumentative interaction in small student groups working in culturally diverse teams, mostly involving technological mediation. The social constructivist framework anchors this work: learning is an active construction in the context of social interaction (Vygotsky, 1978). This kind of learning is characterized by the negotiation of meaning, collaborative sense-making and thus the sharing and construction of knowledge among students working together. In addition to this, I explore implications of cross-cultural psychology for designing pedagogical environments conducive to culturally heterogeneous groups of students (Cole, 1996). I use a variety of analytical tools (social network analysis, discourse analysis, sequential analysis) to analyze the dynamics of social and cognitive processes produced in educational situations. My aim is to use insights from this line of research to design evidence-based instruction that effectively promotes learning. I am particularly interested in developing new technology-enhanced learning environments where cultural differences will, at the very least, be accommodated and perhaps even leveraged effectively to promote learning – make cultural diversity as a resource rather than a problem.

Early research

My dissertation work focused on studying the processes and ways to promote intercultural collaborative learning in online and face-to-face learning environments for university students. Based on the results of my empirical research, I found that members working in culturally diverse groups could have very different expectations with respect to learning and the behavioral motives of others in the group (published in *International Journal of Intercultural Relations*, *2012* and in *Computers in Human Behavio*r, 2014). Collaboration in culturally diverse groups was shown in one of my studies to be less than optimal and may require extra facilitation (published in *The Internet and Higher Education, 2013)*. These results thus laid the foundation for the design of an external, interculturally enriched collaboration scaffold (IECS) — an instructional approach with special attention to the unique cultural backgrounds of the different participants in a computer-supported collaborative learning (CSCL) environment. The results obtained from the last two studies of my dissertation showed that when the IECS was used in the collaborative groups, it promoted positive attitude towards online collaboration, and greater convergence on critical collaborative learning activities (published in *Technology, Pedagogy and Education, 2014*). However, more extensive research is needed to shed more light on the learning effects of using the IECS approach to work in culturally diverse CSCL groups. It was also concluded that the design of the IECS should be revised to incorporate additional elements triggering "challenging and explaining/elaborating" interactions.

Future research

My future research will expand and leverage insights from this line of work on collaborative learning to orchestrate various learning arrangements that can support all learners. One promising approach for promoting intercultural CSCL is use of "dynamic adaptive scripting" (Adamson et al., 2014; Gweon et al., 2013; Wang et al., 2011). In this approach, learning techniques are applied to identify potential or actual problems arising from the intercultural CSCL context and to promote transactivity of talk (i.e., degree to which students refer to each other and build upon each other's contributions during this process). While the IECS promotes productive interactions by designing the environment with suggestions of high degrees of coercion to the collaborating students, a Dynamic Adaptive IECS can help them by intervening on an as-needed basis to get the team back on track. Thus, a CSCL system can be designed to provide scaffolds that are triggered by the automatized analysis of the online CSCL interaction.

In our current research, we have already identified, based on reviews of CSCL literature and interviews with classroom teachers, nine collaborative situations where a scaffold (Hmelo-Silver, 2013) might be effectively applied (e.g., silent too long, one collaborator too over-bearing, team stuck/not making a decision; elaboration on one's own or partner's reasoning). Especially, knowing what students' needs are and their cultural backgrounds, a scaffold may allow us to capitalize on students' cultural diversity in order to trigger creativity and openness to multiple perspectives (e.g., by fostering Internally Persuasive Discourse, see Kolikant

& Pollack, 2015). As we gather more detailed data on critical incidents in intercultural CSCL, we will continue to add to this list. Furthermore, we have conceived the Scaffolding Agent (SA), a cloud-based computational tool that monitors collaborative conversations and on the basis of student inputs (keystrokes, verbal conversation) takes the following actions:

- Identifies problematic situations in collaborative conversations: For example, the SA decides that StudentX in a GroupY has been quiet too long (e.g., not talked, not contributed relatively recently to the group's document).
- Delivers a scaffold to the teacher or to the student: For example, the SA can send an alert to the teacher's computer (e.g., Teacher dashboard, a digital watch) that StudentX in GroupY has been "quiet too long" and requests the teacher to deliver a prompt to the student. Alternatively, the SA could deliver the scaffold (e.g., "Your group could use your input.") to StudentX directly (Quintana et al., 2004).

Ultimately, collaborating students should be able to interact in accordance with principles underlying an IECS but without the actual script to increase self-regulation in the end. This can be done by providing objective feedback on group functioning by augmenting individuals' and team's awareness of their communication inputs and processes (Järvelä et al., 2016). According to research on group psychology, groups are more creative when all members have opportunities to express their ideas and when they feel comfortable doing so. Being aware of behavior and contributions to the group can help group members adjust the way they collaborate, avoid and social problems. This results in building positive affective in-group relationships, which have been shown to promote expression of ideas and greater quality of learning. An Interculturally-Enriched (IE) Feedback Tool based on a client-server system can be designed to provide objective feedback on group functioning to help make group members better aware of individual and group behavior but it will also stimulate them to set goals and formulate plans for improving the group's social performance (e.g., friendliness, affective communication) and cognitive performance (e.g., productivity, quality of contributions). Moving forward, I intend to design an IE Feedback Tool which would include the display of feedback about the relative proportion about oneself vs. one's collaborative partner social–emotional activities (normative articulations that focus on approval, acceptance, agreement, positive affect words etc.) and task-oriented activities (informational articulations that focus on the cognitive activities such as clarification, asking for or giving information etc.).

The research proposed here has the potential to inform the design and implementation of online learning environments that will be responsive to the intercultural context of collaborative learning. Ultimately, these tools can support both teachers and students in the classroom. In addition, this line of research will help not only international learning in virtual and actual classrooms, but also advance intercultural communication and the effectiveness of intercultural teams in the corporate world.

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Fostering Epistemic Growth in CSCL Environment

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Epistemic cognition and CSCL

Epistemic cognition is an area of study that concerns how people acquire, understand, justify, and work on knowledge (Greene, Sandoval, & Bråten, 2016). Research over the past decades has shown its role in students' learning and development (Greene, et al., 2016; Hofer & Pintrich, 2002), and much progress has been made in understanding the nature of epistemic cognition (e.g., the situated nature, cultural relevance, dimensionality) (Chinn, Buckland, & Samarapungavan, 2011; Khine, 2008). Relatively less is known about ways of promoting more sophisticated epistemic cognition among students, especially how such growth could be facilitated in a computer supported collaborative learning (CSCL) context. My main research interests lie in understanding how CSCL could support students' epistemic growth.

Epistemic change

Understanding mechanism of epistemic change is central for examining ways of promoting epistemic growth. Some researchers referred to Piagetian's cognitive disequilibrium to explain the epistemic change process, and suggested that the theory of conceptual change could provide insights in understanding epistemic change (Kienhues, Bromme, & Stahl, 2008; Schraw, Bendixen, & Dunkle, 2002). It was proposed that, much as cognitive conflict plays a role in conceptual change, some kinds of disequilibrium might drive people to change their epistemic cognitions. Further this line of thinking, Bendixen and Rule (2004) proposed a process model for understanding the mechanism of epistemic change. Three components are involved in this process: (a) Epistemic doubt, (b) epistemic volition, and (c) resolution strategies. Epistemic doubt is a form of dissonance involving questioning one's own epistemic ideas about the nature of knowledge and knowing. A key to promote epistemic change is therefore to make students aware of their epistemic doubt and to help them resolve it.

In my research, I draw on this line of research, and proposed embedding *explicit epistemic reflection* in CSCL to facilitate this epistemic conceptual change process. CSCL environment could provide a context where students experience alternative ways of working on knowledge and ideas. However, such implicit approach (engage in inquiry) may not be adequate to promote students' epistemic growth, as indicated in previous studies (e.g., Khishfe & Abd-El-Khalick, 2002). In some cases, what students experienced in CSCL environment may conflict with their original epistemic ideas, and therefore may trigger their epistemic doubt. For example, a student may originally think that knowledge is obtained from authority. After engaging in a constructive Forum discussion, he/she may start to doubt whether knowledge is obtained from authority, or socially constructed. At this point, if we scaffold them to reflect on the epistemic nature of their experience, it may help resolve their epistemic doubt, and therefore improve their original epistemic ideas.

Recent research

In my dissertation, I examined how a computer supported knowledge building environment enriched with explicit epistemic reflection might promote students' understanding of the theory-building nature of science. Knowledge Building, as one type of CSCL model in education, focuses on knowledge creation (Paavola & Hakkarainen, 2005) and community knowledge improvement (Scardamalia & Bereiter, 2006). At the heart of knowledge building is asynchronous online discourse on Knowledge Forum, which was designed to support students' knowledge construction and theory building. Underlying knowledge building is the epistemic theory that knowledge is socially constructed and can be constantly improved through a collective theory building effort. To make such epistemic idea explicit to students, I designed an epistemic model---"little scientists worksheet" to explicitly scaffold students to reflect on their inquiry process in relation to scientists' epistemic practice. Specifically, the model contained sets of epistemic principles and illustrated how four different prototypes of scientists worked on theory building, which mirrored students' inquiry practice on Knowledge Forum. Students used this model as formative assessment to reflect on their own inquiry process. I found that it helped improve student' epistemic practice on Knowledge Forum as well as their explicit understanding of the nature of science, as reflected in the pre- and post- epistemic cognition written tests, discourse, and interviews. This study indicates that to promote epistemic growth, it is important to consider the epistemic implications of the CSCL environment we design, as well as to provide explicit epistemic scaffold to help students reflect upon these epistemic ideas.

To continue this line of inquiry, in my postdoc research, I am testing this postulation in a different CSCL context, where students engaged in collaborative inquiry using a digital text tool (Puntambekar &

Stylianou, 2005). The tool visualizes the connection of the targeted science concepts, and is provided to students as network of resources for their scientific inquiry. It uses both concept map and text as representations to facilitate students' navigation and learning. The concept map mirrors the interrelated structure of the science concepts and phenomenon. Underneath this technological design is the epistemic idea that scientific knowledge is coherent and connected, rather than fragmented. To examine if explicit epistemic reflection could help improve students' epistemic practice. I worked with colleagues and designed a quasi- experimental study. Two classes of 8th graders were recruited in this study. For the experimental class, we provided them with epistemic reflection prompts (e.g., "*how can the connections of concepts in the digital text tool help us do better scientific inquiry*?") while they used the tool to do collaborative inquiry; whereas for the control class, similar procedure was conducted but a conceptual prompt was provided ("*what we want to learn from the digital text tool*"). This study is still ongoing. We will investigate whether and how such epistemic reflection design might affect students' epistemic practice reflected in their concept map work.

Moving forward

As a rise-above, I am currently proposing an epistemic scaffolding framework to understand the support for fostering epistemic growth. Specifically, two kinds of epistemic scaffolding are differentiated: implicit and explicit. Implicit epistemic scaffolding refers to the support (including tool, activities, resources, etc.) that has epistemic implications and potential to *promote* learners' epistemology; whereas explicit epistemic scaffolding refers to the support that intentionally makes epistemic ideas explicit to learners to promote their epistemic understanding (either presented to or constructed by learners). Building on Puntambekar's (2005) distributed scaffolding and Tabak's (2004) synergistic scaffolds model, I propose that embedding explicit in implicit epistemic scaffolds might help maximize the power of support for promoting epistemic growth. This framework could enable us to explain a range of existing evidences account for epistemic change (e.g., Bell, Matkins, & Gansneder, 2011), as well as be used to guide the design of future interventions to support epistemic cognition, especially in a CSCL context. I am planning to develop this line of research, and apply it in different settings.

Besides the design of intervention, I am also planning to investigate further how CSCL processes might contribute to students' epistemic growth. In my previous research, I found that students' theory building discourse on Knowledge Forum predicted their understanding of the social constructive nature of science. In the long run, I am envisioning a systematic investigation on how different components/processes of CSCL including collaborative discourse, epistemic reflection, and epistemic inquiry operationalized in epistemic scaffolding framework might contribute to students' epistemic growth.

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Technology-Enhanced Collaborative Learning for Improved Interactivity, Collaboration, and Flexibility in Higher Education and Corporate Training

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Current position and research within ITEC

I am Postdoctoral Researcher in instructional psychology and – technology and co-PI within the ITEC research group at the University of Leuven (KU Leuven), campus Kulak in Kortrijk. (See: https://www.kuleuven-kulak.be/posterwall/poster/2017/u0037921/ITEC_posters-Kulak_onderzoeksnamiddag2017-TEL.pdf). ITEC is a research group of KU Leuven and imec and brings together researchers of four disciplines (educational psychology, statistics, applied linguistics, and computer science) to collaborate on research topics in educational technology, such as the instructional design and effectiveness, educational statistics and data mining, and information extraction.

I am responsible for carrying out (quasi-)experimental effectiveness research in technology-enhanced learning environments on the basis of theory-driven and empirically validated instructional design principles. This includes evaluation of the impact of choices in instructional design (e.g. task characteristics, task sequencing, learner support) on human learning by analyzing and triangulating the following data sources: 1) observed behavior as captured by tracking technologies; 2) audiovisual processing; 3) cognitive learning outcomes; and 4) dynamic-affective learning outcomes (e.g. goal orientation, perceived functionality, perceived ease of use).

In the next years I will be, among others, involved in the TECOL (Technology-Enhanced COllaborative Learning) project (see https://www.kuleuven-kulak.be/tecol/) aiming at the design, implementation and evaluation of recent features of educational technology and the subsequent LECTURE+ project focusing on the design and evaluation of a data-driven and evidence-based platform for decision support for teachers, room operators and learners in higher education and corporate training, geared towards improving learner engagement in face-to-face, remote, and recorded lectures. Objectives include modelling and enhancing learner engagement through behavior tracking and audiovisual processing, improving the cost-efficiency and scalability of real-time video direction, and demonstrating the added value of interactive technology-enhanced learning.

"Smart education" to promote engagement and effective learning

Over the last 50 years, computers became more and more present in all areas of human society. Also, the field of education has not escaped from this evolution and an important shift towards increased digitalization has occurred (Laurillard, 2002; Yang, Schneller, & Roche, 2015). Next to this, learning analytics is an emerging and promising field for educational research and technology-enhanced learning processes (Conde & Hernández-García, 2015). The TECOL project can be situated in the shift and started in March 2016 at the University of Leuven, Belgium in collaboration with two industry partners, Barco and Televic. The main objective is to enhance interactivity, collaboration, and flexibility in the learning process of University students. The TECOL approach integrates 1) Barco's weConnect system which provides an easy to use, campus-wide user experience for collaborative learning as multiple screens can be shared simultaneously, with 2) Televic Education's collaborationQ platform (a cloud-based platform that provides interactive and collaborative learning activities). The TECOL platform not only offers opportunities for on-campus learning, but also provides the opportunity for connecting remote classes or individuals in an interactive way, overcoming the limitations of distance to enable remote student-teacher interaction.

At the University of Leuven, campus Kulak - including 6 faculties – some of the learning spaces are redesigned and equipped with the innovating educational technology. This campus functions as a living lab, called Edulab (see Figure 1), in which the TECOL solutions and implementations in authentic learning settings are being evaluated and fine-tuned based on a design-based research approach (Barab & Squire, 2004). During the first phase, the project focused on the interactive lecture and the collaborative learning space. Data are collected through focus group interview with lectures and surveys to get insight on the technology acceptance (Davis, 1989) of both students and teachers and learning analytics with be used to more precisely understand students' learning needs and to support teachers to provide optimal feedback and make well-grounded educational decisions based on the content of students' interactions and artifacts (Cuendet & Tormey, 2015; Matuk, Linn, & Eylon, 2015)

Figure 1. Different learning settings at Edulab, the living lab of the TECOL-project.

The first results show that the perceived ease of use, the perceived usefulness and the behavioral intention are high regarding the interactive and collaborative features implemented in the living lab and that effective use of the features significantly improve the technology acceptance ($p < 0.001$). For example, regarding screen sharing, students with experience ($N = 121$, $M = 4.52$) are significantly more positive compared to students without experience with screen sharing ($N = 157$; $M = 3.91$).

Yet, based on the first use cases important questions and challenges revealed to be solved in this context. Teachers stress the need for more informed and evidence-based use of technological interventions during interactive lecture and during collaborative learning settings. To meet this need, future research will set up quasi-experimental instructional design studies to compare different didactical-pedagogical scenarios guided by the recent literature on scripting and orchestration (Dillenbourg, 2015; Raes & Schellens, 2016). Next to this, an ongoing systematic review focuses on the definition of engagement toward detecting learner engagement (from behavioral data and audiovisual data as well), for both online and offline learning, for collaborative and individual learning, to inform instructional design and educational decision making as optimization of learning requires not only to retrieve the useful information and knowledge about learning processes and relations among learning agents, but also to transform the data gathered in actionable information.

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ECW Contribution: Anouschka van Leeuwen

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Theoretical framework

My main research interests are the role of the teacher during collaborative learning, and the supportive role of technology during this process. Collaborative learning is an instructional strategy shown to have positive effects on student achievement (Kyndt et al., 2013), but requires adequate support to lead to the development of the intended knowledge and skills. For example, dividing a class into groups and providing them with a collaborative task does not guarantee that successful collaboration will occur (Kirschner & Erkens, 2013). Part of the necessary support can be offered by digital learning environments, for example by scripting the collaboration and providing prompts. However, the presence of a teacher remains important to provide adaptive support tailored to the needs of each collaborating group (Gillies, Ashman, & Terwel, 2008).

Teacher support is needed to monitor and steer the interaction between students, with careful 'calibration' of the teaching strategies to each group of students (Kaendler et al., 2015). The teacher's challenge is to provide just-in-time interventions, aligned to the needs of each specific group (Lin et al., 2014). To decide in which groups, how and when to intervene requires that teachers first observe and diagnose the progress and quality of the groups' activities (Kaendler et al., 2015). An intervention without diagnosis of the situation within a group can have detrimental effects. For example, a study by Chiu (2004) showed that when the teacher was not aware that students already understood the task, teacher interventions tended to harm students' subsequent problem solving instead of supporting it. Thus the teacher continuously observes and diagnoses students' activities, leading to interventions when needed (Kaendler et al., 2015). Ideally, diagnosing precedes teacher intervention and helps the teacher to decide on the appropriate action in a given situation, at the appropriate time. However, empirical studies (including my PhD research) show that this is far from easy to achieve: diagnosing and supporting multiple groups at the same time places high demands on the teacher, especially concerning staying up to date with each groups' activity and constantly choosing when and how to intervene and how to balance between the needs of the groups and the needs of individual learners within those groups (Van Leeuwen et al., 2015; 2017; Schwarz & Asterhan, 2011).

In the past decade, increasing attention has been given to the idea of using *learning analytics* to support teachers to monitor students or groups of students. Learning analytics (LA) have been defined as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (Siemens & Gasevic, 2012, p. 1). When students collaborate in a computer-supported setting, their activities can be automatically logged, analyzed, and visualized. LA could be a means for supporting teachers to guide collaborative learning by informing the teacher of the current status and progress of each group. However, empirical research in this area is still scarce and primarily small scale. As part of my PhD research, I therefore investigated whether LA tools could support teachers to maintain a more accurate overview of the activities each collaborating group engages in and how LA would influence the frequency and type of guidance they provide for students (Van Leeuwen, 2015). LA were found to fulfill multiple functions: offering an overview of students' activities, steering the teacher's focus towards particular aspects of student collaboration, and providing information for choosing the appropriate intervention.

Plans for moving forward

In the studies I have conducted so far, initial evidence was found for the supporting role of LA for teachers to provide real time guidance to collaborating students. However, many challenges remain. The premise of LA is that it offers "actionable knowledge" that enables the teacher to immediately translate the information intro concrete learner support of some kind. However, between the step of providing teachers with metrics about learners and actual changes in student learning lies a process of sense making and decision making from the teacher. The teacher has to reflect on and interpret the metrics, and decide whether and if so, how, to act (Hoogland et al., 2016; Verbert et al., 2013). A recent review of LA tools to support teachers indeed shows that merely providing teachers with LA that summarize student activities is not enough (Sergis & Sampson, 2016). Teachers need to know how to interpret this information, and what pedagogical actions to derive from them.

This raises the question how, on a micro level, teachers use LA. LA are an additional source of information in the classroom context, in which already a magnitude of stimuli require the teacher's attention. Information should be visualized in such a way that allows for effective allocation of the teacher's resources and which helps to achieve the teacher's goals (Sergis & Sampson, 2016). In other words, we need to analyze the teacher's behavior while interacting with LA as input for effective design of LA tools for teachers. When LA are not tailored to the one responsible for driving the interventions, in this case the teacher, no actual changes in student learning will occur and LA will not be effective. In the project I am currently working on, we therefore investigate different types of LA that support the teacher in different ways, ranging from summaries of student activities to advising the teacher what to do. To develop these LA, we also employ eye tracking techniques to study how teachers interact with and interpret the LA provided to them (Van Leeuwen et al., 2017).

Employed methods

My PhD project started with exploratory questions concerning the demands placed on teachers while guiding collaborating students, followed by experimental studies to examine the effect of LA support tools for teachers. These two types of research designs asked for both qualitative and quantitative methodologies. Concerning qualitative methods, I interviewed teachers using cued retrospective recall techniques. Furthermore, log data of teacher-student interactions were coded. Concerning quantitative methods, statistical analyses were used to study the effects of LA tools to support teachers. The experimental setup was realized by developing simulation studies that took authentic student data derived from previous classroom studies and displaying these data in real-time. The simulation setup made it possible to show the same situations (i.e., vignettes) to all participating teachers. In the experimental condition, the simulation was enhanced with LA. For the studies I am currently working on, I have recently also employed eye tracking techniques to study how teachers make sense of LA.

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How Tangible User Interfaces Can Contribute to Collaborative Language Learning

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Research summary

I am currently working on a research project about developing a Chinese character composition game based on augmented reality (AR) with paper interfaces. The motivation of the study is derived from the potential of AR in educational applications (Wu et al., 2013) and the benefits of tangible user interfaces in collaborative learning (Schneider et al., 2011). Five design principles are extracted to guide the system design according to a systematic literature review on AR in education and pedagogical design of Chinese character learning. They are 1) visualized contextual information; 2) radical-derived character learning; 3) group-based hands-on activities; 4) differentiated learning curves and 5) enabled classroom orchestration. All the system-based activities are designed in line with Chinese language curriculum for primary 1 and primary 2 students in Singapore. The study seeks to provide the field of CSCL with contexts and insights into how to apply AR in classroom learning and in which way tangible user interfaces can contribute to collaborative language learning.

Theoretical framework

My study is guided by sociocultural views of learning, with which language learning is viewed as a semiotic process attributable to participation in social activities, rather than internal mental processes solely by the individual (Lantolf & Thorne, 2006). According to the theory of situated cognition which emphasizes that people's knowledge is constructed within and linked to the activity, context, and culture (Brown et al., 1989), learning is social and not isolated, as people learn while interacting with each other through shared activities and through language, as they discuss and exchange ideas. In this sense, learning vocabulary from the abstract definition in the dictionary only teaches basic parts of a language. Learning how the words are used in authentic social interactions is more important for language learners.

Innovations in language education have been targeted towards ways of enhancing learners' vocabulary learning beyond rote learning and mechanical practice (Lam et al., 2001). Computers and the Internet have been put into use in assisting language learning, and their positive effect on developing vocabulary acquisition or Chinese character learning has been reported in a large number of studies (e.g., Lam et al., 2001; Sung, 2014). The instantiation ranges from web-based reading tasks with glossing support to online personal vocabulary learning systems or application. With the development of touch-screen device technology, the focus of design has been shifting from simple visual aids to interactive interfaces (Zhan & Cheng, 2014). However, as Kukulska-Hulme and Shield (2008) summarized in their review paper of mobile device assisted language learning, existing studies focus more on content delivery but few studies considered how to use the new devices to support interaction and collaboration. Furthermore, most of systems for vocabulary learning are designed specifically for individual learning, though some propose group activities, but most disregard formal classroom learning.

Therefore, in my study, I am not just working on which or to what extent technology can provide enrich or vivid contextual information for language learning. I am more interested in how technology can be used to trigger more productive interactions among group learners, where the use of target words and their meaning-making may take place. It is acknowledged that AR, as one kind of technologies that combine augmented information with contextual information may provide a new experience in learning (Bacca et al., 2014; Prieto et al., 2014). My research focuses on investigating how to integrate AR in classroom learning for co-location and multiple user collaboration and, in this process, how language learners appropriate and may benefit from the learning environment design with collaborative Chinese character composition game.

System instantiation

Figure 1. demonstrates the examples of the paper-based user interface and work process. To "augment" paper, we chose near-field communication (NFC) which is a specialized subset within the RFID family. Like RFID, NFC has advantages of cost-effectiveness and stability of data communication. NFC tags can be easily hidden and attached to papers or cards. Different from RFID, NFC owns short distance security for information, so card information can be read without mutual interference when many of them are displayed on the table at the same time. When students in a small group working on the activity, a set of radical and component cards (approximately 50 cards), as well as the structure cards, is prepared for them to composite Chinese characters. In each group, NFC reader, as an input device, connects to iPad which is used as an output device to display the

results of the cards being manipulated. We also design a series of accessory cards to help students complete the task at their own group pace. Students in every group can decide by themselves when and which accessory cards that they need to use to complete the task. These accessory cards may trigger more communication and negotiation during the process of finishing tasks, and students may learn how to collaborate and communicate with one another effectively. In addition to the cards for students, we prepare certain cards for help teachers orchestrate collaborative learning activities in the classrooms.

Figure 1. paper-based user interface and work process.

Research to date

The system development is coming to an end. Our school-based intervention will be conducted in two Singapore primary schools with 4 Chinese language teachers and 5 classes from April 2017 till April 2018. During that time, we will further refine the system based on the feedback from teachers and students, following design research approach. Beyond evaluating students' attitude toward Chinese character learning using the system and assessing its effects on students' self-efficacy and learning performance, I seek to put more efforts on investigating whether and how the AR-based system with the paper interface can contribute to arise more effective social interactions in language learning classrooms. To achieve this objective, it is planned to record the teaching practices and the learning trajectory of target groups using the system. When collecting data on teachers' moment-to-moment instructional practices and students' group work, two researchers will observe lessons, take notes and capture the whole class/target group process by video cameras. Chronological representation and annotation tools such as Studio Code or ELAN will be used to help analyze and visualize video and audio data. Furthermore, user log data captured from using cards will help triangulate video data. To the end, user log data can provide valuable information to diagnose the chief difficulties and common mistakes in learning Chinese characters for young beginning learners.

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Designing Collective Learning in Mixed Reality Environments

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Abstract: My research is concerned with the design of collective learning experiences in mixed reality environments, examining students' embodied interactions and learning in terms of reflection, collaboration, and performance. I employ design-based research methodology, utilizing co-design with teacher partners to create complex inquiry activities for implementation in authentic classroom settings. Using mixed methods research designs, I analyze students' learning artifacts and outcomes, as well as collaboration and embodied interaction behaviors though video analysis.

Introduction

My research broadly lies at the intersection of science inquiry, the Learning Sciences, and Human-Computer Interaction, and is focused on the interaction and experience design of mixed reality environments, including related software applications for learning in science and health topics. I earned a PhD in Education (Curriculum Studies & Teacher Development) and Knowledge Media Design from the University of Toronto (2015), and my thesis examines embodied interactions and collaborative learning in a mixed reality learning environment, known as EvoRoom. On graduating with my doctorate, I was awarded a SSHRC postdoctoral fellowship (2015-2017) at the University of Illinois at Chicago (UIC) in the Electronic Visualization Lab, working with Professor Tom Moher, working on improving students' conceptual understanding in collective and embodied learning environments. My career goals are to *design* emerging learning technologies for science inquiry and *research* new and meaningful ways of enhancing learning and communication for children through these technologies.

PhD research

My dissertation, *Designing EvoRoom: An immersive simulation environment for collective inquiry in secondary science*, is based on the idea that complex inquiry designs can facilitate students working as a community, and engage in knowledge construction and inquiry practices that allow a collective knowledge base to support individual reflection and group collaboration. The main goal of this research is to develop and refine a new form of collective learning and to test the theories that underlie the design of the innovation.

Theoretical perspectives

The design of EvoRoom is based on the Knowledge Community and Inquiry (KCI) pedagogical model, where students are supported to work as a collective scientific body, creating a knowledge base and using it as a resource for subsequent inquiry (Slotta & Najafi, 2012). Transforming classrooms into "knowledge communities" can engage students in more authentic scientific inquiry, for example with small groups of students working together like research teams within a broader scholarly community to jointly negotiate issues of a shared problem. By generating and building upon each other's ideas, students take greater responsibility ultimately fostering their own understanding. To this end, EvoRoom seeks to engage students in collective inquiry as a knowledge community within a mixed reality environment, where the physical environment is intertwined with a virtual world.

Method

With a design-based research methodology, as characterized by iterative cycles of design, evaluation and revision, the study spanned over two and a half years. Following the co-design method, I engaged in a close design partnership with a secondary school science teacher, and led the design and development of EvoRoom: a simulated rainforest with wall-sized displays capable of transforming through a 200 million year trajectory as students explored habitats and species. By creating an immersive simulation of a Southeast Asian rainforest, EvoRoom created a setting by which students could engage in technology-supported face-to-face knowledge work as a collective. The designed interactive and collaborative experiences allowed for co-located students to explore concepts in biodiversity and evolutionary biology, using the simulation as an evidentiary base. Students interacted not only with their individual devices and their own small groups, but also with the class as a whole through networked tablet computers, allowing aggregated visualizations to emerge in real time on Smart Boards, which provided ambient feedback about class progress and supported teacher-led discourse. A multi-week curriculum prepared students with preliminary ideas and expertise.

The design of EvoRoom encompassed the broader curriculum, as well as technology materials (e.g., projected displays, student and teacher tablet application interfaces, visualizations of the collective knowledge base) and activity sequences. The thesis describes a series of three iterative designs, presenting key features that enhanced students' experiences within the immersive environment, their interactions with peers, and their inquiry outcomes. My investigation examines the nature of effective design for such activities and environments, and the kinds of interactions that are seen at the individual, collaborative and whole-class levels.

Using a mixed methods research design to complement the design-based methodology, the study employed both qualitative and quantitative evaluations to adequately represent a complex curriculum with numerous components, particularly since the enactments were in the context of an authentic science classroom with few available experimental controls. Quantitative measures were used to determine learning outcomes and student attitudes towards the intervention. Several sets of qualitative data were coded into quantitative data (Chi, 1997) and statistically analyzed (e.g., Student's t-test, ANOVA). Student artifacts produced during the EvoRoom curriculum were evaluated with such a method. Qualitative evaluations were primarily used to analyze long passages of text, such as video transcripts, to explore emergent content themes and embodied interactions.

EvoRoom was shown to support significant learning gains in evolution and biodiversity concepts, and identified patterns of interactions that supported student inquiry. A set of design recommendations is drawn from the results of this research to guide future design or research efforts. Findings from my thesis research inform our understanding of how other mixed reality environments can be used to support inquiry-based models of learning, how knowledge communities can be formed around immersive, shared experiences, and how they can be conducive for science education.

Postdoctoral research

My postdoctoral work at UIC addresses the need to support students in working with conceptual ideas within mixed reality environments, questioning how learners transition between more active forms of interactions (both physical and social) supported by mixed reality environments to more reflective, idea-centered thinking. The context of the mixed reality environment, known as WallCology, engages students in discovering ecological relationships amongst imaginary species presumed to occupy the walls of their middle school classroom. The knowledge work I am investigating concerns students' understanding about a community of species that lives in several controlled ecosystems (each assigned to a different group of students). Only by amassing their collective knowledge can they create a complete model of all of the species' relationships. With input from co-design teachers and the wider research team, I am designing and developing applications to support students' modeling of ecosystems as food webs, and their reasoning and predictions around those food webs. I follow student progression in their collaborative modeling and examine how they advance individual and collective knowledge.

Future directions

Upon completing my postdoctoral fellowship, I will seek opportunities toward a career in design and research. I plan on submitting manuscripts on my PhD and postdoctoral research in the Spring and Fall of this year respectively, in order to strengthen my profile as a potential candidate in traditional academic settings as well as research institutes. With my career goals of designing emerging learning technologies and researching meaningful ways of enhancing learning and communication for children through these technologies, I intend to continue the line of research supporting students' conceptual knowledge development within mixed reality environments through collective inquiry. I am interested in experimenting with various forms of immersion afforded by interactive media and by tangible media, and am excited by the prospects of extending this research to more informal learning environments (such as museums or science centers) and additional scientific contexts.

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Enhancing Collaboration and Assessment: A Learning Analytics Approach

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Abstract: The key idea is to draw insights from rich learning theory models, and pair them with computational models that automatically capture the essence of what is happening in a collaboration situation for achieving impact on learning. My approach always starts begins with identifying a real-life problem. Then I investigate this problem through theoretical lens and formalize this understanding in models that demonstrate explanatory power in connection with outcomes that have real applications. The next step is to design, extend and apply data mining methods in ways that leverage the deep understanding in order to construct computational models that are capable of automatically generating useful information. Finally, with the automated technology in place, the next stage is to design interventions that lead to better learning and collaboration. I am pursing this research program in multiple parallel contexts including computer supported collaborative learning (CSCL), social media, and massive open online courses (MOOCs).

Factors that support collaborative learning

What factors influence students' behavior and performance in collaborative learning contexts and how? Inspired by social cognitive theory, I propose various dynamic CSCL models of learning to simultaneously examine the mediation and causal relationships among different constructs (e.g., social ability, perceived enjoyment, group efficacy etc.) and reveal each factor's influencing mechanism on student behavior online (e.g. posting frequency, posting delay time) (Xing & Goggins, 2016) and performance (Xing, Kim, & Goggins, 2015). Using confirmatory factor analysis, Partial Least Squares path modeling and mediation analysis methods, results revealed an intertwined relationship among the factors and a different influencing structure for each factor on social and learning performance. Combining social cognitive theory and statistical modeling, this line of work draws insights into factors that sustain online collaborations and influence student learning.

Automated assessment of small group collaboration behavior and performance

How do teachers continuously track and assess small group collaboration for the purpose of adapting and individualizing their instruction? I have designed new methods and tools to support teacher decision making in various online contexts by providing automatic processing of students and groups' digital trace data. 1) Informed by group cognition and activity theory, I designed a cascaded support vector machine algorithm and a statistical modeling method to model learners' conversations and behaviors simultaneously in a small group online environment for learning math (Virtual Math Teams). I further employed various clustering (Xing, Wadholm, & Goggins, 2014, 2015; Xing & Goggins, 2017; Xing, Chen, & Macinkowski, 2017) and classification (Goggins, Xing, Chen, Chen, & Wadholm, 2015) algorithms to automatically characterize and assess individuals' and groups' behavioral patterns and performance in this environment. 2) To detect academically at-risk students in an online discussion forums context (e.g. MOOCs, Sakai), I designed a rule-based genetic programming algorithm that can forecast student performance before the course ends and provide actionable information to teachers to personalize intervention design for these at-risk students (Xing, Guo, Petakovic & Goggins, 2015, Xing & Goggins, 2015; Xing, Chen, Stein, & Macinkowski, 2016).

New educational media design, evaluation and management

1) In MOOCs or online communities, as the volume of data grows, learners or information seekers usually find it difficult to access and locate useful information. Grounded in common ingroup identity theory, I incorporated learner's behavior data with textual data and designed a web-based system to provide dynamic intelligent support for information retrieval in large-scale online discussion forums (Xing, Goggins, & Introne, in progress). 2) Incorporating interaction network analysis, hashtag analysis, and geographic information systems (GIS) applications, I proposed an analytical framework to help web managers better manage their web resources via computational metrics and 3D visualizations (Xing, Guo, Fitzgerald, & Xu, 2014). This approach enables me simultaneously elaborate principles behind successful collaborative technologies; refine the system design, and understand how they mediate learning.

Future research

Affect detection and computing

Affect and emotion are fundamental to human experience and have profound influences on perception, communication, decision-making and learning. Using a cognitive affective framework, I plan to use statistical modeling to uncover how affect influences students' collaboration behavior and learning. Then, relying on this theory-based understanding, I will develop methods and systems that can automatically sense and respond to students' affect to improve collaboration and learning.

Design the future collaborative learning system

Today, with the affordances of information technologies, education can happen anywhere, anytime. How can we provide intuitive ways for identifying right contents, right collaborators, and right services in the right place at the right time? I envision a collaborative learning system powered by data with a flexible and extensible architecture to provide theory-informed actionable intelligence for learners to collaborate in a ubiquitous way.

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An Exploration in Learning Through Art, Science, and Making

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Abstract: This study aimed to tackle the challenge of providing context, a reason for learning, and space for youth voice for a diverse group of teenagers. I explored how a multidisciplinary art and science maker workshop focused on sound encouraged a diverse set of young people to understand sound as energy and creatively express themselves. This study found youth exerting their agency through the artifacts created in the workshop and evidence of youth gaining understanding of the science of sound.

Educational philosophers, theorists, and researchers have time and again called for teaching that connects to learners' lived experiences, allows for agency, and respects the learner (Dewey, 1938/1963; Esach & Schwartz, 2006; Papert, 1980; Sieler, 2000). As these recommendations have been made for almost one hundred years, it is clear that it is not easy to achieve such a learning environment. This study explores a novel approach to connecting learning to youth's lives, creating space for agency, and improving science knowledge, all through a multidisciplinary art and science maker workshop. In particular, this study synthesizes ideas of funds of knowledge (Moll, Amanti, Neff, & Gonzales 1992) and constructionism (Papert, 1980) along with self-expression through art, in a project on sound. I chose sound as it is easily relatable to individuals' lived experiences and is also a challenging science concept to understand (Asoko, Leach, & Scott, 1991; Esach & Schwartz, 2006; Houle & Barnett, 2008; Linder, 1992; Pejuan, Bohigas, Jaen, & Periago, 2012; Wittmann, Steinberg, & Redish, 2003).

Many physics education researchers point to the need to contextualize sound to help students understand this concept (e.g., Esach & Schwartz, 2006; Hernandez, Couso, & Pinto, 2012; Linder, 1992). There are several prominent ways to create context in a learning environment. Progressives and critical pedagogues alike have advocated for allowing learners to have voice in their education (Dewey, 1900/1956; Moll, Amanti, & Neff, & Gonzales 1992). When youth feel respected for their existing knowledge and skills, they engage and grapple with challenging science content (Basu & Barton, 2007; Basu, Barton, Clairmont, & Locke 2009; Seiler, 2001). Another proven way to create context is through incorporating making in a learning environment. Making comes out of Papert's theory of constructionism (1980) which suggests that individuals learn best through the production of artifacts, digital or physical, while conversing about these experiences. Making provides context by giving students a purpose to learn vital information in order to complete their artifact (Fields, Kafai, & Searle, 2012; Kafai et al., 2013b).

Along with providing context for learning, it is important to respect the learner. Respecting the learner means the educator has to honor the diverse experiences that students bring into the learning environment. However, this comprehensive respect can be challenging. For example, studies that focus on individuals' funds of knowledge tend to only privilege a few persons' experiences (Hammond, 2001) instead of the broad array of individuals in the learning environment. It can also be challenging to create a learning experience that does not assume a static notion of youth culture in an attempt to create a connection to youth (Ares, 2006). One approach to combat these issues could include multidisciplinary STEAM (science, technology, engineering, art, and math) projects. Incorporating art into a learning experience could potentially allow for the expression of a diverse set of experiences and knowledge. Expression through the creation of artifacts has been successful in bringing youth voice into learning environments (Barton et al., 2013; Barton & Tan, 2009; Gonsalves, Rahm, & Carvalho, 2013). Creative self-expression using the knowledge and practices of a particular context which helps individuals develop their identities and perhaps advance their positions in the world is agency (Barton & Tan, 2010; Basu, Barton, Claremont, & Locke 2009; Hoechsmann & Poyantz, 2012; Sheridan, Clark, & Williams, 2013). Along with engaging youth agency, incorporating the production of art into a learning experience allows making to become a part of the learning environment. Making of a physical object is inherently multidisciplinary (Blikstein, 2013) requiring engineering, design, mathematics, and more to complete a project. When making is combined with art this often results in increased engagement with the learning experience (Kafai et al., 2013a).

This study investigates how an art and science making workshop helps youth gain in science knowledge and have agency over the learning experience. In particular, this study explores an electronic crafting project focused on sound. Youth built their own functioning speaker and created their own sound recording as part of a collaborative art installation. Through conversations, writing, and making, youth explored both the science of sound and how sound artists create environments through sound. The following research questions underpin this study:

1. In what ways were a diverse set of youth able to express their agency within this making learning environment?
2. In what ways did youth improve in their understanding of sound through creating a sound piece and speaker?

Conceptual framework

This study aims to determine if youth are able to have agency and find relevance and intention for understanding challenging science content by participating in a multidisciplinary art and science maker workshop. Research on funds of knowledge, electronic crafts, and challenges to learning sound underpin the curriculum for this study, along with Dewey's experiential learning, Papert's learning theory of constructionism, and the view of art as means of self-expression. Figure 1 shows a visual of my conceptual framework, which gives making more space than self-expression and science. It is my hypothesis that the intersection of self-expression and science through making will allow youth to experience their agency while finding relevance for learning and understanding challenging concepts.

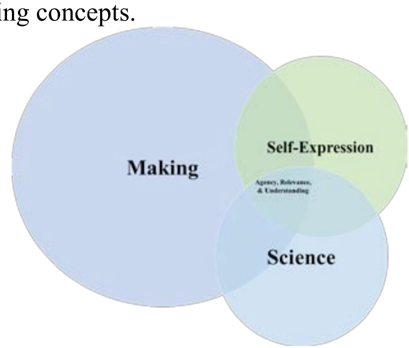

Figure 1. Conceptual Framework.

Methodology

I conducted a concurrent embedded design, mixed methods, Early-Stage/Exploratory research study (Creswell, 2009; IES, 2013). This study was part of the summer workshops for an outreach program conducted by a large science museum in the Northeastern United States. My workshop ran over four days in July of 2016. I worked with ten rising sophomores: five male and five female who were all fifteen years old. No individual identified as White. Through four 3.5-hour sessions, youth learned about sound from a scientific and artistic perspective while making a functioning speaker.

Future studies

I believe the next step for this research would be testing to see if this curriculum could work with a broader set of participants who do not have both an aptitude for and a love of STEM fields. It would be interesting to implement this curriculum in a studio art classroom and to see if I get similar results or not.

A place of missed opportunity from this study was that the youth were given time to critique and rework their sound pieces, but were not given this opportunity for their speakers. It would be interesting in a future study to have youth critique and rework their speakers. I would want to know if, through a reworking of their speakers, youth would learn more about sound, electricity, and engineering, along with design. Would more youth feel that they were able to express themselves creatively through their speaker designs?

I feel the exhibit at the end of the workshop was an important learning experience. Communication comes in many forms and in this workshop, several of the youth spoke about how learning to create a sound piece broadened the ways they knew how to express themselves. Similarly, several youth mentioned how speaking to the exhibit attendees boosted their confidence and improved their oral communication skills. In a future study, it would be interesting to explore more fully the role that an authentic audience (the attendees to the art exhibit) played in youth's learning and agency.

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Peer Assessment: Students Helping Peers to Learn

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Summary of research

Peer Assessment: Students Helping Peers to Learn

Despite the importance education has placed on writing, students are not meeting standards. These shortcomings have serious, short- and long-term consequences. Students need more opportunities to practice writing, receive individualized feedback, and respond to that feedback through revision. But who will provide the feedback? Teachers often do not have enough time to provide detailed, specific feedback—especially as class size increases. One possible solution is peer assessment. Peer assessment is the quantitative evaluation and qualitative feedback of a learner's performance by another learner of the same status (i.e., no obvious authority figure). A substantial amount of research has demonstrated that peer assessment is effective at helping students build writing skills. However, as with most pedagogy, the effects are not always consistent, which warrants a deeper investigation into how peer assessment helps students learn. My research uses cognitive theories of writing, feedback, learning, and transfer to examine three aspects of peer assessment:

1) How does the feedback students provide differ from that of instructors?
2) How does peer assessment improve learning?
3) Under what circumstances is peer assessment most effective?

To better understand the nature of peer feedback, I developed a theoretical model that not only identifies important features of feedback but also explains how these features support revision behaviors (Nelson & Schunn, 2009; Patchan, Schunn, & Correnti, in press). This theoretical model consists of nine feedback features (i.e., summarization, praise, mitigating language, problem descriptions, solutions, localization, explanations, scope, and focus of feedback), two possible mediators (i.e., agreement and understanding), and two observable revision behaviors (i.e., implementation rate and revision quality). I tested this theoretical model in several contexts in order to understand these three aspects of peer assessment.

How does the feedback students provide differ from that of instructors?

First, I applied my theoretical model to comments received from college-level peers and instructors. In general, students provided comments that were similar to instructors (Patchan, Charney, & Schunn, 2009). However, there were some differences between the students and the professors. For example, students provided more praise than the professors. Other times, students were more similar to one type of professor. For example, students provided a similar amount of solutions that focused on substantive issues as a writing professor, but both of these commenters provided fewer solutions than a history professor. In an undergraduate physics class, students received more and longer comments from their peers than from their non-native English speaking TAs (Patchan, Schunn, & Clark, 2011). Moreover, the students provided more high prose feedback (e.g., audience, clarity, flow, length) than the TAs. Importantly, students provided a similar amount of feedback focused on substantive issues as the TAs. These results suggest that although students may value certain features more than instructors (e.g., praise), overall their comments are often consistent with instructors' comments.

How does peer assessment improve learning?

What is often overlooked in current peer assessment research is how students learn from the process of peer assessment. I examined this question in two different populations: undergraduate students and kindergartners learning to write lowercase letters. In one study, I examined the benefits of *receiving* peer feedback. An in-depth analysis of undergraduate peer comments revealed that students were more likely to implement a comment that was localized, however revisions related to these comments were less likely to improve the quality of the paper (Patchan, Schunn, & Correnti, in press). Similarly, they often ignored higher-level comments (e.g., issues with clarity, transitions, support), however revisions addressing these issues were more likely to improve the quality of the paper. Analyses of possible mediators revealed that *problem understanding* was related to implementation—that is, a comment was more likely to be implemented if the author understood the problem, and certain features like solutions and localization were more likely to improve an author's understanding of the problem (Nelson & Schunn, 2009). Overall, these findings suggest that students should be focusing on feedback that describes higher-level issues, and certain features (i.e., localization and solutions) may help students address these problems.

In a separate study focused on the benefits of *providing* peer feedback, I examined how teaching kindergartners to provide specific feedback to their peers improved their lowercase letter writing ability (Patchan, Puranik, Talbot, & Digon, 2014). Students who provided peer feedback made fewer place and size errors than students who completed their typical writing instruction. Moreover, when students correctly identified or diagnosed errors, they were less likely to make the same error even after controlling for whether they made the error before engaging in peer feedback. These results suggest that students as young as kindergarten can gain and use metacognitive knowledge about writing from providing specific feedback to peers.

Under what circumstances is peer assessment most effective?

Many instructors and students worry about whether students of all ability levels are capable of helping their peers. In general, higher-ability peers provided more criticism with solutions that were focused on higher-level issues than lower-ability peers (Patchan & Schunn, in press; Patchan & Schunn, 2015). Moreover, higher-ability peers described more problems in the lower-quality texts than in the higher-quality texts, whereas lower-ability peers did not make this distinction. These findings suggest that higher-ability peers and lower-ability peers use different strategies when providing feedback. Perhaps, higher-ability peers comment on all the problems they notice, resulting in more problems with lower-quality texts than with higher-quality text, whereas lower-ability peers may limit the number of problems detected in all papers regardless of the quality (e.g., detect two problems per prompt in each paper reviewed). Importantly, lower-ability authors may benefit more from the feedback provided by lower-ability peers. They are more likely to revise based on comments from lower-ability peers, and these revisions are more likely to improve the quality of their drafts. These findings support a zone of proximal development explanation: perhaps, the feedback from higher-ability peers focuses on issues that lower-ability authors are unable to fix even with the additional help provided by their peers.

Current research projects

To further examine these questions, I am currently working on several projects. I have been working with a team of undergraduate and graduate students who are coding features of peer feedback collected from an undergraduate, introductory philosophy course. This very rich dataset affords the examination of multiple research questions. First, I plan to confirm the current version of the nature of peer feedback model in a new writing genre (i.e., philosophical arguments). Then, I will expand the model to include relationships among features (e.g., localized vs. not localized solutions; high prose solutions vs. low prose solutions), types of solutions (e.g., focused vs. unfocused solutions), and other revision behaviors (e.g., add, delete, or reword text). Moreover, participants in this study completed the peer assessment process on two separate papers, which allows me to explore how students' reviewing behaviors change as they gain experience assessing their peers' work. Finally, I will further examine how the benefit of providing feedback versus receiving feedback differs depending on the quality of the text being reviewed and the ability of the peer who provided the feedback.

I am also addressing questions about motivation and perceptions of peer assessment in STEM classes. I have established collaborations with faculty from the Department of Engineering and the Department of Chemistry to integrate peer assessment of writing in the discipline. After piloting and refining the writing and peer assessment tasks, we will examine the effects of rating-focused versus comment-focused forms of accountability (i.e., reviewing grade based on the consistency of peer ratings vs. reviewing grade based on the helpfulness of comments) on the quality of peer assessment. In addition, we will identify the underlying factors that explain why students and teachers often have negative perceptions of peer assessment and develop an intervention that targets these factors in order to promote more positive perceptions.

Finally, I plan to extend my program of research to younger populations. In particular, I am coordinating a collaborative effort to examine the effectiveness of a problem-posing task combined with computer-assisted peer assessment on improving middle school students' mathematical competency. To this end, I have submitted a proposal to NSF. In the meantime, we have recruited two middle school teachers to pilot the problem-posing and peer assessment tasks. In this pilot study, the teachers will also provide feedback for all student work so that we can experimentally manipulate the source of the feedback (i.e., teacher vs. peers). This pilot data will serve as a basis for identifying where middle school students' peer feedback is lacking and what additional support will be needed to help them construct feedback that looks more like teacher feedback.

The Hidden Curriculum of Online Learning: Discourses of Whiteness, Social Absence, and Inequity

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Equity: Going beyond access

My research deals with cultural discourses that perpetuate the existing societal inequities in CSCL practices. I define equity as the fair distribution of opportunities to learn within a fair learning context and regard CSCL practices situated into social, political, historical, and economical discourses to explore how students *live* the curriculum with respect to notions of equity and social justice. For example, my most recent ethnographic work in digitally-meditated contexts illustrates how online experiences are defined in relation to the discourses of Whiteness: the hidden curriculum of online education maintains cultural hegemony and creates inequitable or unfair learning experiences through cultural differences.

I follow the argument that equity is not about quantitative differences or sameness of educational inputs or outputs but pedagogical approaches in which social, political, and historical structures inevitably affect day-to-day classroom interactions (Esmonde, 2009). As an emerging learning scientist, my research agenda expands this idea through three interwoven themes.

Frist, I go beyond the notion of a digital gap (or digital divide) to conceptualize the issues related to equity and diversity in CSCL. Critical research regarding social justice and equity has limited its scope to simply the issue of access to technology or the Internet, leading to a common misconception that equity and diversity can be addressed if individuals have access to educational resources (Harasim, 2000). This idea is inherent in research regarding open-flexible access. Such claims, however, assume that access to online environments alone is sufficient to foster diversity and support equity, completely disregarding the way macro-level societal dynamics can manifest themselves and operate to reproduce inequities that exist in society at large.

Second, I challenge the rather taken for granted notion that online learning environments democratize education by giving voice to those who are otherwise unheard. When issues of participation are considered, much research has argued that the appearance of equal conversational relations implies the presence of equitable learning conditions. This perspective assumes that giving individuals a chance to participate to an online discussion is more democratic compared to traditional classrooms (Swan & Shih, 2005). Measuring the quantity of messages posted or received, researchers have concluded that the nature of communication in online learning environments provides equitable learning conditions since those who are traditionally shut out of discussions – people from under-privileged cultural groups, women, minorities, or even people shy in nature – can benefit from the increased possibilities for participation. However, just because students can login to the digitally-mediated environment and interact with others does not ensure equitable learning experiences. I analyze how power relationships, otherness, privilege, or marginalization in relation to the material and symbolic conditions within which the daily learning practices are embedded. My work illustrates that democratizing education does not end when individuals gain access to online learning environments. My work shows that "having voice" or "being heard" are subject to the rules of engagement and the process of identification in learning contexts.

Third, I introduce a new concept, social absence, through which online education research can better understand and study online experience. Social absence is based on the concept of social presence; a concept that has long been employed to study human experience in online learning environments. Social presence is defined as the degree to which individuals represent themselves and perceive others in digitally-mediated (Rourke, Anderson, Garrison, & Archer, 1999). It is constructed dialogically; it not only facilitates individuals' practices in online contexts but also conveys socio-historical norms, values, beliefs, and perspectives that individuals bring into online learning environments (Oztok, 2016). I argue that a comprehensive understanding of online experience, however, should go beyond how individuals represent themselves and further include the identifications that individuals consciously filter-out when they create their online existence. I term these consciously filtered-out identifications social absence (Oztok, 2014). Therefore, I regard social absence as the extent to which particular identifications are not represented in one's social presence. I formulate the relationship between social presence and absence in relation to the concept of impression engagement (Goffman, 1959) and demonstrate that identification in collaborative work is not only articulated by what is represented but also defined by what is filtered-out in that particular representation. I operationalize the concept of social absence to show the ways that individuals may hide behind their relative anonymity to overcome exclusion based on their socio-cultural identifications. In order to explain how individuals have differentiated learning experiences based on their identification, my work illustrates how individuals are caught in the double bind (Spivak, 1999) of identification, revealing the otherwise hidden effects of cultural hegemony on the construction of self in CSCL settings.

Taken together, my research agenda revolves around ways of conceptualizing the relationship between macro-level discourses and micro-level learning contexts: the ways in which material and symbolic realities of daily life manifest themselves and effect the ways that individuals identify themselves based on their social presence and absence. I conceptualize this relationship with respect to the concept of hegemony (Gramsci, 2000) to show that cultural hegemony leads to an inequitable CSCL practices or contexts.

Theoretical and methodological approaches

At the theoretical level, my work is bricolage of ideas for and approaches to questions concerning equity and social justice. I drive theories from critical pedagogy, curriculum studies, and learning sciences to investigate the ways in which culture play a role in collaborative practices. In particular, I focus on how members of group work are positioned in relation one another and how that discursive positioning have an impact on their learning.

At the methodological level, my work is derived from the ethnographic approaches. I employ critical discourse analysis to analyze the otherwise hidden manifestations of social, political, historical, and economical discourses.

Future Work

My immediate research agenda is concerned with the current hype and enthusiasm regarding MOOCs and the increased promotion of online certification programs that are offered by public school boards or higher education institutions in their commitment to accommodating public needs, widening access to materials, sharing intellectual resources, and reducing costs (Anderson, 2008). While I acknowledge and appreciate this altruistic mission, such courses may in fact perpetuate inequitable learning situations if not enough attention is paid to the points highlighted above. Many students continue to experience inequity through the problems associated with digital divide. Yet, educational inequity still exists even when one has crossed the digital divide and has access to digital resources. My research agenda aims to expand the argument that access does not solve nor provide equitable learning conditions since equity is a continuous process that requires awareness of the material realities of students with different cultural backgrounds, as well as a commitment to solidarity through diversity and difference.

I regard my previous work as a basis for my future research agenda rather than as a conclusive solution or a blueprint for a problem. As such, I hope my work will spark thought, controversy, debate, and further research on this topic.

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Understanding Learning Through, With, and About Data

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Introduction

My research is situated at the intersection of data visualization, human-computer interaction, and socially facilitated learning. Thanks to ever-increasing integration of technologies into people's daily lives, the relationship most people have with data is changing. Generating and interpreting data are now part of the fabric of everyday life and are fundamentally transforming the way people understand the world, yet research has not kept up with understanding how people are making sense of data—particularly data visualizations— outside of formal settings and how designed learning environments can prepare learners to be mindful consumers of data both in and outside the classroom setting. We know from a large body of work conducted in classroom and lab settings that interpretation of unfamiliar complex data is a challenge for learners even with extended interactions and significant curricular supports in place (e.g. Edelson, Gordin, & Pea, 1999). We also know that while novel interactive technologies have great potential for supporting learning, they must be implemented carefully to ensure that they engage users with content rather than distract from the intended learning goals. My work, situated in this emerging problem space, addresses how people learn through, with, and about data and how multi-user and off-the-desktop systems can engage learners in collaborative data exploration.

Theoretical framework

My work draws heavily on sociocultural theories of learning, emphasizing the role of dialogue both as a vehicle for learning and as a means for studying it. I view learners' meaning-making with data representations as a form of mediated action (Wertsch, 1998), in which meaning is constructed through interactions between the learners (or "agents") and the mediational means with which they are engaging, including other agents in the space and the objects with which they are interacting. My analyses focus on "learning talk" (Allen, 2002) among participants as they engage in interactions.

I am particularly drawn to free choice learning environments like museums, where visitors approach exhibits in groups and engage in open exploration of content guided by their own interests (Falk & Dierking, 2000). Because many of the data representations people encounter in their lives exist outside of formal classroom settings, studying collaborative sense-making about these representations in museums can help inform educators and designers how learners interpret data in a variety of out-of-school contexts.

Museums seeking to engage their visitors in memorable experiences are often drawn to novel interactive technologies like tangible interactives, multi-user touchscreens, and whole-body control exhibits. Theories of embodied cognition and embodied learning suggest great potential for these interactives to augment learning through physical interaction. My research posits that novel interactive techniques may have particular mediational affordances for "hooking" people into data exploration, yet we know relatively little about how they impact learning outcomes in authentic contexts. I apply embodied cognition theories to the design of informal learning environments to examine how novel interactive systems can support interpretation of data.

Methodological approaches

To study the affordances of interactive visualizations for facilitating learning talk, I engage in design-based research (DBR). Museum visitors often approach an exhibit without a specific learning goal, so the dialogue they have with companions—how they evaluate presented information, connections they make to prior knowledge and experiences, explanations to each other, and questions they ask each other—greatly influences their learning experience. Studying this dialogue provides insight into how this meaning is being made and how designed elements of the exhibit can help productively mediate learning conversations. Iterations of my interactive exhibits are tested *in situ* using video and audio recordings to capture and analyze visitor interactions and spontaneous learning talk using qualitative and quantitative methods.

Though prior work has established some widely accepted types of learning talk in museums, there is no universally appropriate coding scheme for understanding informal learning. In some analyses I have conducted primarily qualitative coding to characterize visitor talk (e.g. Roberts et al., 2014). However, recent work has confronted the need to validly quantify learning talk in order to conduct A/B testing to compare the affordances of competing designs. My solution was a coding method called Scoring Qualitative Informal Learning Dialogue (SQuILD) that provides a way to quantify talk through a combination of *simultaneous* and *magnitude* coding (Roberts & Lyons, 2017). While it is not always appropriate to distill rich qualitative data to numerical values, such quantification is crucial for making objective comparisons of competing designs.

Past work

Designing digital rails to foster scientific curiosity around museum collections

In this collaborative DBR project between Northwestern University and the Field Museum of Natural History we have sought to capitalize on touchscreen technologies incorporated into a new permanent exhibition at the Field Museum, the Cyrus Tang Hall of China. While the focus of this project is engaging visitors with tangible objects rather than data visualizations, many similar challenges of interaction design exist, for example balancing the amount of attention visitors give to the interactive features of the exhibit with how much they are able to engage with each other. Our design iterations of these touchscreen interfaces explore how technologies can foster curiosity about objects as evidenced by visitor dialogue and how location-aware sensing systems can augment visitor experiences while informing museum practices.

CoCensus: Collaborative exploration of U.S. census data

The *CoCensus* project at UIC iteratively designed and tested a multi-user embodied interaction museum exhibit in two urban museums that lets visitors explore and play with U.S. census data. Through variations in the physical layout of the space, the graphical representations of the census data, and the design of the controller for manipulating the interactive system, we sought to understand how design—and in particular whole-body interactive design—can support groups of learners in collaboratively making sense of complex data.

Creating and disseminating tools to teach with demographic data maps

CoCensus stemmed from prior work at UIC studying learning with interactive data maps on a project collaborating with undergraduate and graduate faculty in multiple disciplines to support them in incorporating web-based GIS census data tools into their classroom practices. Through design team meetings with faculty we co-created curriculum units to support student exploration and interpretation of these census data maps. Analyses examined the design process of developing the curriculum units, and in particular the articulation of learning objectives that emerged in design team meetings, and explored the narratives created by students in these curriculum units and the relationship between those narratives and the data informing them.

Future work

Interactive visualizations for collaborative exploration of data

The *CoCensus* project scratched the surface of this emerging research area, but there is much more to learn about how designers can scaffold data interpretation and how people are making sense of visualizations. I am particularly interested in moving beyond census data and incorporating other kinds of visualizations beyond GIS maps to more thoroughly explore the problem space of shared data exploration. Through work with other kinds of data sets (e.g. biodiversity or climate data) and other activity structures (e.g. task-oriented or goal-based scenarios rather than open exploration), my ongoing work in this area will contribute to theory and practice of developing data visualizations for out-of-school learning.

Novel, off-the-desktop interactive techniques for supporting learning

CoCensus research compared learning talk by users of a tablet-controlled version of the exhibit with those in a full-body interactive version of the same exhibit, finding that handheld tablet users significantly outperformed the full-body controller participants in the amount and depth of the learning talk. This ran contrary to expectations based on embodied cognition theory and prior work in embodied interaction design, including pilot work on that project. The surprising results revealed many avenues of research still in need of exploration in light of the expanding interest in utilizing so-called natural user interfaces for learning.

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Growing Teamwork Competency in 21st Century Learners

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Abstract: My research is focused on nurturing 21st Century learners, particularly in the area of teamwork and collaboration. This summary includes my research goals and background, theoretical frame, methods, and plans for moving forward.

Introduction

Teamwork is one of the important competencies for 21st Century learners to thrive in an increasingly complex and connected world. Although teamwork is not a new concept, it is easily taken for granted, i.e., assuming that students know how to engage in teamwork. Studies have shown that students do not necessarily practice good teamwork and collaboration skills. For instance, students tend to use a divide-and-conquer approach rather than a collaborative meaning-making one (Tan, Chai, Lee et al., 2010) or/and do not check on their team members' progress (Salas, Sims, & Burke, 2005). While it is important to nurture teamwork, this can be challenging due to various issues including the difficulty of assessing teamwork in classroom contexts, and integrating activities to scaffold teamwork processes in schools.

With the goal of enabling learners to grow their teamwork competency, my research examines teamwork and collaboration processes as well as the socio-cultural aspects of the classroom, facilitated in part by collaboration technology. I have a background in Information Systems, which looks at the organizational effects of information technology usage. My PhD thesis was focused on the characteristics of learners and technology, and its impact on learning outcomes. As part of the thesis, I conducted a field experiment with undergraduate teams, and found that when students used collaboration applications with high sociability (e.g., those with a synchronous chat), they perceived higher process satisfaction and a more positive social environment. On the other hand, when students used a system with more visibility (e.g., public wikis), this resulted in higher academic performance and students' solution satisfaction.

From my research into characteristics of technology and learners, I have deepened my area of research into the mechanisms of such collaborations. I now put the spotlight on the behaviors and processes that take place within a team which could lead to team effectiveness in a blended learning environment. This path of inquiry has led me on a journey that started with an assessment measure of teamwork, followed by the pedagogical design of formative teamwork assessments in authentic learning environments and the involvement of learning analytics. In that sense, while I have tunneled into the mechanisms of collaboration and teamwork, I find myself broadening in topical areas wider than before.

Theoretical frame

Based on the literature and pilot tests, I have conceptualized a domain-neutral measure of teamwork competency that currently comprises four dimensions: coordination - organizing team activities to complete a task on time; mutual performance monitoring - tracking the performance of team members; constructive conflict - dealing with differences in interpretation between team members through discussion and clarification; and, team emotional support - supporting team members emotionally and psychologically.

Together with the measure, I have developed a pedagogical framework in which to nurture teamwork (Koh, Shibani, Tan et al., 2016). In this sense, that has become my theoretical framework. This lens is titled the "Team and Self Diagnostic Learning" (TSDL) framework and key informing pedagogies are experiential learning (Kolb, 1984), collaborative learning (Duffy & Jonassen, 1992; Hung & Nichani, 2001; Vygotsky, 1978), and the learning analytics process model (Verbert, Duval, Klerkx et al., 2013). TSDL aims to develop students' teamwork competencies and collaboration skills and comprises four stages: team-based concrete experience, self and team awareness building, self and team reflection and sensemaking, and, self and team growth and change.

Learners begin with *team-based concrete experiences* namely, the collaborative inquiry task. Learners can engage in teamwork in any form and way such as a face-to-face discussion or online collaborative writing for a report. This concrete experience enables the learner to interact with his team members and engage in teamwork in more participative ways. After the teamwork experience, an *awareness-building* activity is designed, which is primarily through self and peer ratings resulting in a visual analytic. This data visualization attunes leaners to the collaboration process through making visible the foregrounded teamwork competency.

Next, *self and team reflection and sensemaking* follows. A deliberate set of activities is designed to enable learner reflection, to make sense of the awareness information. Learners need to evaluate the visual analytics, ask and answer reflective questions, diagnose their learning and create new insights. Goal-setting and future-oriented questions are particular effective strategies (Phielix, Prins, Kirschner et al., 2011) and are planned as part of this stage. This should be done individually and as a team.

Lastly, the TSDL framework suggests that change will occur after this cycle of activity, and is marked by the stage of *self and team growth and change*. Based on Kolb (1984), the successful resolution of the dialectics of concrete observation and abstract conceptualization will generate internal change in the learner. When learners make sense of their teamwork behaviors, and realize areas of change and areas to change, they will perform new and better behaviors. This change can also be pictured over time in the visual analytic.

Methods

I am a mixed methods researcher and I try to integrate both quantitative and qualitative data to make sense of phenomena. Furthermore, multiple methods are used to measure the processes and outcomes of the intended study. I have also employed design-based research as the overarching methodology for several projects.

Pathways forward

My work is deepening and broadening in the following two areas. First, deepening the research and practice nexus through design-based research interventions in schools. I am now implementing the TSDL framework in authentic collaborative inquiry curricular in two High Schools. This project is a collaborative endeavor as the teachers have been co-designing in the project with me since 2015. Through this project, I hope to develop mid-range and micro learning designs and principles to enhance the framework in various classroom contexts and increase its utility to teachers and students.

Second, expanding and innovating teamwork measures with technological affordances. My foray in learning analytics has primarily been to make visible processes and mechanisms of collaboration and teamwork. This work is ongoing and a direction I am heading towards is using learning analytics as a decision-support tool for teachers, to track students' activities and identify students' at-risk (i.e., with low teamwork competency) through a teacher dashboard.

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Seeking and Designing for Educational Equity Within the Maker Movement

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Abstract: My research focuses on the establishment, implementation, and maintenance of informal educational maker programs within public libraries. My goal is twofold: first, to consider how these programs are created through intersections between different actors within the organizations themselves as well as the wider ecosystem of the Maker Movement, and second, to consider how this understanding can contribute to the design of educational maker program that specifically focus on equitable opportunities for nondominant/alternate maker communities.

Introduction

Over the last decade, the "Maker Movement"—a technologically enhanced extension of the Do-It-Yourself (DIY) movement that focuses on the use of novel prototyping tools for the creation of personalized projects—has become popular both in mainstream society as well as in educational contexts. While many people in education circles have embraced maker practices and perspectives, there have been many critiques of the movement—namely that it often tends to serve a limited demographic (male, white, and middle-class) and consequently, the particular values of these groups (e.g., Vossoughi, Hooper, and Escudé, 2016). Rather than attributing this weakness to the explicit design of programs and activities however, my research looks more broadly at the ecosystem surrounding educational making. Most current educational research on making has concentrated more specifically on the particular 'moments of making'—examining what and how participants learn—and thus tends to focus on making at the level of single participants and programs. While this work has yielded many insights within learning and teaching theory, I step back and consider how educational making always comes into existence because of wider matrix of factors, including people, spaces, tools & materials, organizations, and ideologies. By carefully considering the way that these elements intermingle and mix to contribute these maker experiences, we can further our understanding of how educational making might inadvertently create exclusionary spaces. Only by doing this, I argue, can we actively move toward designing more equitable maker experiences.

Theoretical framework

In order to understand these particular questions of implementation, I primarily draw from Actor-Network Theory (ANT), which is an analytical approach to studying how particular phenomena always result from the interactions and ever-shifting relationships between different actors, whether objects, people, ideas, or groups. ANT is described as a "material-semiotic" method (Fenwick and Edwards, 2012) that derives from scholarship in science and technology studies (STS). Specifically, ANT grows out of research on the social construction of technology (SCOT), which focuses on how technological shifts result from social interactions and negotiations amongst people rather than on the features of the tools themselves. ANT steps back from this proposition by reintroducing the importance of the material world, considering how 'nonhuman' actors are still as important as human actors in determining the ultimate impact of particular innovations or phenomenon in society. From this perspective, the approach ANT shifts away from considering the fixity or stability of particular phenomenon (whether trends, countries, or even scientific facts) (Latour, 2005) toward the idea that these are continually brought into being through "discursively heterogeneous relations that produce and reshuffle all kinds of actors", which can include all manner of things like "human beings, machines, animals, 'nature', ideas, organisations, inequalities, scale and sizes, and geographical arrangement" (Law, 2009, p. 2). My goal in using ANT is therefore to shift away from thinking of "making" as an already agreed-upon or understood practice or concept, and instead think about how it is actively enacted or "performed" (Latour, 2005) through the continually forming and shifting relationships between different human and nonhuman actors that interact over time and space.

Methodology

For this research, I conducted a 16-month ethnography at two educational maker programs established in public libraries: 1) a small workshop-based maker program located in a suburban library branch within a middle-class, predominantly white suburb, and 2) a large mentor-based maker program situated within a multi-branch library system in a diverse, mostly working-class urban setting. Both are informal education initiatives are aimed toward a youth and/or family audience, and are well connected to the wider 'maker network,' either through their funding and support systems (receiving grants/material support from well-established organizations), or their networking activities (informal partnerships with other 'maker' communities/programs, as well as conference presentations, articles, and interviews). I wrote field notes based on my attendance of the on-the-floor activities and workshop, as well as behind-the-scene gatherings such as staff meetings and trainings. I also conducted semi-structured interviews (averaging about 40 minutes) with staff members from both programs (16 total) that focused the logistics of planning, implementing and maintaining these programs, as well as their perceptions about the purpose of these programs and educational making in general. Following Latour (2005), my ANT analysis of this data focused on 'tracing the associations' not only within the programs themselves, but also to other sites and actors within the wider ecosystem of educational making (e.g., through partnerships and collaborations with other sites, funding and sponsorship agreements) for the purposes of discovering particular themes and categories of engagement.

Findings

Through my analysis, I have focused on the mechanics behind the establishment, implementation, and maintenance of these two informal educational maker programs. With regard to these programs' establishment and implementation, I discovered two main axes of influence: 1) the *organizational structure* of the program vis-à-vis the library at-large and how this influences who facilitates the programs (its *staff*), and 2) the *neighborhood situation* of the program and how this influences who the *participants* of the program are, in terms of demographics and their expectations/needs. While both programs were initially founded upon similar premises and goals then, what they eventually became and were able to accomplish in terms of learning and engagement was profoundly shaped by these factors. With regard to these programs' maintenance over time (with regard to the wider Maker Movement), I discovered two ongoing practices. First, managerial staff at both programs were regularly engaged with what I call 'hustling' for support, or active attempts to move around both human and nonhuman actors with the aim of capitalizing upon external sources of funding, materials, and other support. Second, staff were involved with producing 'spin' about their programs, or the practices of recording, translating and representing program activities for outsiders, often inscribing them within desirable narratives that 'fit' within the larger network of educational making. While these acts are often shielded from popular view, I argue that these 'behind the scenes' activities are foundational to enactment of educational making in society. Not only do they shift the nature of the libraries themselves as institutions of public education and service, but they also shape *what* educational making means to participants and facilitators, and consequently, *how* these activities can promote equitable learning and engagement.

Future work

As indicated above, my future research goals are to draw from the insights of this ethnographic work (focused on the conceptualization, planning and implementation of two informal educational maker programs) in order to create a framework for designing equity-focused maker programs. ANT is a useful tool in that is enables researchers to ask not only *who is* supported through the existing actor-networks, but *who is not* and *why*. In the Maker Movement, there are certainly some programs, activities, and initiatives that are held up—and consequently supported—above others because of how well they *fit* within popular definitions of 'successful' making. However, there are many communities and on-the-ground practices that are often not counted, considered or backed precisely because they *do not fit*. Thus, my future goals are two-fold. First, I am interested in identifying these alternate networks of making through ANT analysis, specifically looking at the practices of non-dominant maker communities. Second, I hope to generate new activity structures and frameworks that can be implemented within both formal and informal educational spaces than can promote these alternate channels of success and engagement. Only by more carefully considering this interaction, I believe, can we truly work toward the overall goals of achieving equity through educational making.

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Exploring the Embodied Aspects of Imaginative and Creative Processes

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Introduction

At the most general level, my research interests involve exploring the ways that young people make meaning through face-to-face interactions, and as mediated by digital technology. A focal point for me is the embodied and material aspects of these meaning making interactions through the lens of sociocultural learning theory. In my doctoral work, I explored these themes in the context an interactive art museum exhibit. One central area of exploration involved the ways that visitors could be prompted to use their bodies to "pose" with artworks to support their interpretive processes (Steier, 2014). Currently, I am exploring imaginative and creative processes, and the ways that certain material, gestural, and digital representations support these processes in different settings including physics classrooms and in professional architecture practice.

I am currently exploring these themes through two quite different research projects, and one of my goals for the coming years is to look across these cases to develop richer understandings of these particular kinds of collaborative meaning making processes. The first case is through a project called ReleQuant, and involves the design and implementation of a web-based module to teach concepts of general relativity and quantum physics for upper secondary physics students. The module supports small group discussions through simulations, short films, and thought experiments, as well as teacher-led discussions. In light of my broader research interests, my particular focus in this project is in the ways that students use gesture and imaginative processes to make sense of a key feature of this theory – that gravity is the result of curved four-dimensional spacetime. Currently, my colleagues and I are developing a second iteration of this module to be tested in 7 high schools in the coming months. More details about the research methods and theoretical perspectives for this project will be provided below.

My second main research case involves collaboration with Norway's National Museum of Architecture and several professional architecture firms. In this project, we are exploring the role that digital materials play in architectural processes. From the museum's perspective, this presents an important challenge because digital artifacts are not typically included in an archival collection, and there are interesting questions about how to display these materials in a meaningful way to visitors. My focused research interest lies in the ways that digital resources support architects creative processes and mediate the ways they imagine what future-designed spaces will look and feel like. One outcome about this project will be an exhibition at the museum, which we will be developing later this year.

As I begin to look across these cases, I am interested in exploring the ways that particular digital environments can support face-to-face, collaborative, creative and learning processes. In what ways might processes of imagining spacetime in physics classrooms be similar to the imagining performed by architects? How can we explain these processes as social and embodied? From a design perspective, are there features of activities and digital resources that mediate these kinds of meaning making processes? Below, I will briefly describe my theoretical approaches, my research methods, and my goals for future work.

Theoretical approaches

My research is theoretically informed by a sociocultural approach to meaning making and incorporates notions of embodied interaction. First though, I would like to specify the kinds of activities that this research addresses as they both inform and influence these theoretical stances. I am interested in face-to-face learning interactions by small groups of participants in formal and informal contexts**.** In rough terms, my approach to learning as a social process not only influences how I view and understand processes of learning, but also informs the questions that I ask and the processes and phenomena that I pay attention to.

The stance that I take in this research is that meaning making is a socially and culturally situated process in which co-participants jointly construct interpretations of their context (Wertsch, 1991; Vygotsky, 1978; Suthers, 2006). These processes are mediated by signs including psychological tools such as language and gesture, and involve the internalization and externalization of these interpretations (Wertsch, 1991). I am particularly interested in the physical aspects of these processes, not only in gesture as a physical sign system, or physical space as a context, – but in how we treat the body, how we understand its relationship to physical space, and how we incorporate the material and semiotic properties of artifacts, physical tools, and digital technologies. Accordingly, I incorporate a view of embodied interaction (Goodwin, 2000; Streeck, Goodwin, LeBaron, 2011) to elaborate and situate the role of physicality within a sociocultural framework. Embodied interaction, is characterized as the study of how people "organize their body movement and talk when they interact with one another in the material world" (Streeck, et. al., 2011, p. i). This approach implies that these physical sign forms are not distinct systems from language – but that meaning making occurs through their mutual elaboration.

Methods and data

My overall research designs are informed by Design-Based Research (DBR) methods. DBR involves the introduction of designed, theoretically-driven activities, resources, or settings into a situated learning context (Brown, 1992; The Design Based Research Collective, 2003). The designed intervention is then iteratively developed and refined as it simultaneously researched in situ. This methodological approach is important for my work for several reasons. First, my projects and cases involve collaborations with other institutions and partners, including schools, museums, teachers, etc. DBR accounts for these as authentic and highly situated settings. A second important aspect of DBR is that research and design processes are iterative as the intervention and ensuing theoretical understandings are continuously refined. The iterative nature of this process supports the developments of learning resources that address the needs of my partners, while also allowing me to refine my findings about meaning making processes.

The primary data collection method for my research involves the use of video and audio recordings. In particular, I build on my own previous research in exploring innovative use of camera technology to record video from a variety of angles and perspectives to highlight and reveal multiple features of situated action. Multiple camera angles support attention to interactional features including gaze, orientations, gesture, and dialogue. These materials are typically supplemented by field notes, interviews, and the productions of participants. Interaction analysis methods (Jordan & Henderson, 1995) serve as the primary analytic method in order to describe and understand meaning making processes. This involves a systematic data reduction strategy, and allows for extremely rich explorations of meaning making processes.

Future directions

I would like to mention three specific goals as I take this research forward. First, I wish to expand on my earlier work looking at meaning making trajectories of young people by considering larger scales of time and place. How might I shift to exploring these meaning making processes across, for example, an entire school year, or multiple museum visits? Second, I have recently been investigating notions of "imagination" as an important 21st century skill that extends across disciplines. To date, I have looked at high school physics classrooms, and now at professional architects. What happens when we consider imagination as a foundational skill and process in its own right? What are the relationships between imaginative processes across settings and disciplines? I feel that this is a particularly rich area of exploration in light of increasingly sophisticated representational and digital media. Finally, I would like to continue to develop a research program that attends to participants embodied experiences within the framework of sociocultural theory.

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Mid Career Workshop

CSCL 2017 Mid Career Workshop

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Introduction

The Mid-Career Workshop is in its third year. Whereas the Early-Career Workshop provides an opportunity for CSCL and learning sciences researchers early in their careers to discuss their own research, to discuss early-career challenges with peers and senior mentors and to initiate international networks related to their research topics, the Mid-Career Workshop focuses on issues that become relevant later on (e.g. approximately 10 years after the doctorate, during the tenure seeking process, or right after obtaining tenure) in academia, but also in museums, NGOs and in R&D positions in the private sector.

Upon reaching the mid-career stage, researchers enjoy a built up reputation, a storehouse of experience and expertise, an elaborate professional network, and frequently more security than experienced at earlier career stages. By this stage, researchers have produced a substantial body of impactful research, and yet, they may feel their early career work was constrained by concerns related to periodic reviews and political vulnerability. The mid-career stage may be experienced as a new opportunity for risk taking towards more ambitious research agendas, with the promise of greater impact. Yet, this new found freedom is paired with greater administrative responsibility, and further challenges come in the form of increased frequency of invitations for external professional involvement that may eventually be experienced as "too much of a good thing". How does one navigate this new landscape without becoming over-committed? How does one achieve a healthy balance of community service and personal research?

Our vision is to co-construct the day we spend together with the participants. Laureates will present perceive challenges involving their research, professional programs, service, teaching, funding, and outreach. Some of the questions we will address involve both building a research community and taking charge of one's career trajectory:

- How do you cultivate a community around a shared research topic to advance knowledge and create broader impacts over time?
- How do you build and then acquire the **skills to manage** a center or institute or large grant project with inter-institutional collaborators?
- How do you build **design-based research** that has a strong team (researchers, designers, programmers) so what gets built can last and scale?
- How can mid-career scholars bring together their expertise/experience to **collaborate** more effectively in research projects/grant writing (especially internationally)?
- How do you strategically manage the path from Associate to Full professor 5-6 years after tenure?
    - Challenges to navigate? Pitfalls to avoid?
    - How did mentors help you? What kind of mentors did you need for promotion to Full?
- How do you get the opportunity to be in positions of leadership and how do you strategically choose which positions to do (e.g., journal editorship, etc.)?
- What strategic publishing decisions have you made so your work has a broad impact on the research base? On practice?
- How can mid-career non-educational researchers interested in SoTL research integrate into the educational research community?
- How can one move from getting smaller grants to big grants ?

Looking at Technology in CSCL

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Abstract: In her conceptualization of writing technologies, Haas (1996) refers to the relationship between technology and materiality, asking herself about the nature of computer technologies and their impact on writing. In my work, I examine this specific relationship looking at how the design of technologies shape and configure educational practices. My interest is in accounting for how learning and teaching become material through the use of technologies and how this materiality has implications for the development of CSCL learning and teaching practices. By looking at technologies, their content, functionalities and affordances (and not only through them), my work aims to point at the constitutive entanglement of material and social aspects of CSCL artifacts in collaborative learning and teaching practices.

The central place of "C" (computers) in CSCL

Educational technologies matter. They are not designed in a vacuum. They carry ideologies within them and reflect practices and values. Yet, in the field of education, little attention has so far been paid to their material properties, scope, shape and/or history of the various technologies that are tested or/and introduced into educational institutions. Technology is often seen either as transparent, encouraging a positive acceptance of technology without any consideration of possible negative effects, or as all-powerful and self-determining (Haas, 1996). In the field of CSCL, questions pertaining to the material aspects of human activities have been the object of attention within, for instance, the cultural historical approach (Vygotsky, 1934/1997). Such issues have recently been renewed by Johri and Olds (2011), Sörensen (2009) and Fenwick et al. (2011) who speak of a sociomaterial nature of educational technology and its concomitant role in enacting change in our educational practices. In particular, Sörensen (2009) has pointed at "a blindness toward the question of how educational practice is affected by materials and how these materials are much more than mere artifacts to advance educational performance" (Sörensen, 2009:2). This perspective on the sociomateriality of learning has mainly drawn from research on science studies conducted by scholars such as Latour (2005), Knorr Cetina (2001) and Miettinen et al. (1999). Its main tenet is that learning, which is situated in the material world (i.e. classrooms, worksites, virtual spaces, community projects, social movements, and so forth), is sociomaterial as its "energies, processes, motives and outcomes are fully entangled with material practice, knowledge representations (e.g. text, pedagogy, curriculum content) nature, time, space, technologies and objects of all kinds" (Fenwick et al. 2011:vii). Such an understanding of sociomateriality conceptualizes learning as situated and embedded within an activity, context and culture (Lave, 1988) and bounded to the artifacts making such activities possible (Rabardel, 1995; Nardi and Kaptelinin, 2006). It refers to learning as everyday practice where technologies are at a central position between the individual learner or teacher and the cultural practice within which learners and teachers as individuals operate. Moreover, a sociomateriality lens on learning questions the idea of treating CSCL artifacts as a given and as disembodied from aspects pertaining to learning practices that technologies embody in their design and that are enacted when they are used. A focus on the sociomaterial invites us to dig into the heterogeneous and multiple relationships that assemble and configure contemporary CSCL practices (Cerratto-Pargman et al., 2015; Nouri and Cerratto-Pargman, 2016).

A research- and design-oriented perspective of CSCL practices

My interest in how technology configures learning and teaching practices and how our educational practices shape the technologies we interact with, has brought me to combine a research-oriented perspective, mainly inspired by the socio-cultural approach (i.e. Vygotsky, 1934/1997; Rabardel,1995; Engeström, 2001; Kaptelinin and Nardi 2006,) with a design-oriented perspective (Collins, 1992; Brown, 1992). In this workshop, I would like to discuss how these two perspectives have jointly developed throughout my work and how they have conducted me to study emergent educational practices and their material conditions. (Cerratto-Pargman et al., 2017).

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Exploring Social, Cognitive, And Representational Issues in Learning Through Playful Co-Design: A Mid-Career Workshop Proposal

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I seek to understand the impacts of design innovations on learning while also building contexts within which such innovations are created, integrated, and sustained. In particular, I explore (1) *How* we can design and implement innovative learning environments that enhance the ways we teach, learn, and collaborate; and (2) *What* such efforts reveal about teaching and learning. My work investigates the cognitive, social, technological, and representational issues surrounding student learning and teacher practice within constructionist—and more recently, playful—environments. I focus on designing to support science inquiry, which encompasses work on scientific representations and computer-supported-collaborative learning; and co-designing educational innovations, including data visualizations for teachers, and game-based learning in afterschool and professional development contexts.

Designing to support science inquiry

I began my scholarly career with a deep interest in how people learn from visual representations. My dissertation problematized the visual design of standard representations such as cartoons, comic books, and tree diagrams. Through clinical interview-based teaching experiments, I explored the interaction between their visual design; people's intuitive narrative approaches to sensemaking (Bruner, 1991); and the complexity of the scientific topics represented, including natural selection, viral infection, and phylogenetic relatedness (e.g., Matuk & Uttal, 2011).

Building on this work on representations, I now investigate technological and curricular innovations that support students in developing the interrelated literacies of science and graphs, topics that are traditionally taught in isolation from one another. Through design-based classroom research, I document how graphs can both support students' scientific explanations and reveal their common misunderstandings within realistic science inquiry contexts such as cancer and cancer treatment (Uk, Matuk & Linn, 2016). Through classroom experiments, I have also explored the relative value added of critiquing, constructing, and collaborating on graphs on science learning (Matuk, Zhang & Linn, 2017); and the notion of visual ambiguity through analysis of the discourse of middle school students around a graph of climate change during a web-based inquiry science investigation (Matuk, under review).

A second research area is on fostering collaborative learning through technology. As a postdoc, I led a design and research program around a new tool, the Idea Manager, in the Web-based Inquiry Science Environment (WISE) (Matuk et al., 2016). The Idea Manager is based in Knowledge Integration (Linn & Eylon, 2011), a constructivist framework that recognizes students' diverse ideas about science, and specifies a pattern of instruction that elicits these ideas, adds new normative ideas, and then guides students in organizing, distinguishing among, and integrating these ideas into a coherent understanding. As such, the tool breaks down the process of scientific explanation into manageable steps, guiding students through multi-day inquiry units to gather, sort, and distinguish evidence for explaining such topics as the seasons, chemical reactions, and cell division.

Through design-based research and comparison studies on the Idea Manager's classroom implementation, I identified features that promote students' negotiation of shared understanding (Matuk, Sato, & Linn, 2011); the discipline-specific ideas with which they struggle, when support is required, and for whom (e.g., low vs. high prior knowledge students) (McElhaney et al. 2012); and curriculum strategies for supporting students' productive uses of shared knowledge (Matuk et al., 2013; Matuk & Linn, 2014, 2015). Currently I am exploring the value added of such tools for scaffolding scientific explanations, and investigating the learning implications of how collective knowledge is shared and negotiated. This work offers views into students' thinking that are otherwise inaccessible through traditional assessment, with implications for designing to address students' diverse needs.

Co-design to support agency and innovation

My process has become increasingly informed by user- and learner-centered design (Soloway, Guzdial & Hay, 1994) and by design-based implementation research (Penuel et al., 2011), both of which value the participation of stakeholders in educational design through activities that allow them to combine expertise with researchers in order to prototype technologies that align with shared goals. By giving people voices in shaping the tools of their practice, and the environments in which they learn, I aim to promote the relevance and sustainability of designs.

Through annual participatory design workshops, I coordinate the goals of WISE teachers, researchers, and technology developers in conceptualizing new tools for visualizing and acting upon students' thinking. Working with logged student work and automated assessments, my efforts informs the design of tools that will reveal patterns in students' thinking, and lead to more timely, targeted guidance. My efforts contribute a unique teacher-centered perspective to the areas of learning analytics and classroom orchestration. I have explored technologies that enable teachers to use evidence from student work to customize their instruction (Matuk, Linn & Eylon, 2015); and participatory design strategies for eliciting and translating teachers' needs into designs (Matuk et al., 2016). I am currently exploring what teachers' designs reveal about their values in science inquiry, and will investigate the impacts of real-time technologies on teacher practice and student learning.

Extending my explorations of co-design into playful learning contexts, I have partnered with the Institute of Play (instituteofplay.org) and established a summer institute during which pre-service teachers, NYU students of educational design, and in-service teachers co-design game-based learning (GBL) experiences (Matuk, 2016, bit.ly/iop-codesign). Follow-ups with participants suggest the institute's positive and growing impacts: Teachers have taken on leadership roles as game experts in their schools, and have pursued GBL initiatives at both the school and classroom level. My research explores co-design as a lens onto, and reflection of the tensions between stakeholders in educational innovations. With a second institute offering planned, I will soon begin a project to examine the effects of a year-long professional development and mentorship program on supporting social sciences teachers in using games and play in their classrooms, and developing their agency and identities as designers.

Moving forward, I aim to integrate these existing foci to explore learning issues around science, visual narrative, and emerging technologies, in the context of playful co-design. Toward this goal, I have been engaging youth and graduate student game designers in co-designing comic book-inspired science games. One research focus is on the process of supporting the design of playful learning experiences (Matuk, Levy-Cohen & Pawar, 2016). A second is on the roles of play, and of visual narratives that mingle fantasy, science and history (e.g., bit.ly/wov-measles), in developing youth's science learning, systems thinking, and 21st century skills.

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Creativity in Post-Secondary STEM Teaching and Learning

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Abstract: This project will examine the relationship between creativity and STEM in post-secondary teaching and learning contexts. It will draw from a range of sociocultural and critical theory about creativity, learning and science and will employ qualitative, collaborative and participatory approaches within a DBR framework in order to examine STEM learners and learning contexts, re/define notions of creativity and scientific creativity and transform post-secondary STEM learning and teaching in ways that center creativity.

Research summary

The scientific problems issues that we face today are increasingly complex and open-ended and have transdisciplinary (social, political, economic) dimensions (Kawasaki & Toyofuku, 2013; de Sousa Santos, 2007). These issues will require future scientists and professionals to think beyond the disciplinary silos of majors and work in transdisciplinary collaborative environments to devise solutions that are sustainable, culturally relevant, and equitable. This will require not only the ability to communicate and collaborate, but also to engage in creative practices that will lead to the ongoing innovations necessary for sustainable futures. Future innovators will not only need to generate novel solutions, but also pose original questions in order to study given problems. In order to bring innovative practices into STEM there needs to be deliberate approaches to developing STEM learning contexts that foster problem posing and solving with creativity as a central approach.

Undergraduate STEM education research has largely and historically been situated within the science disciplines and described as a "loose affiliation of related fields" (Singer, 2013). It is an inherently interdisciplinary field that combines a science or engineering field with education research and has already generated insights to prepare students to better understand and address contemporary and future societal challenges. Recently there have been efforts to coalesce and define Discipline-Based Education Research (DBER), including a dedicated 2013 special issue of *The Journal of Research in Science Teaching* and a synthesis study of the state of DBER. The U.S. based synthesis study (National Research Council, 2012) articulated goals of DBER that include understanding how people learn the concepts, practices and ways of thinking of science and engineering and to identify approaches to make science and engineering education more broad and inclusive (NRC 2012, p. 54). This seminal report emphasized the importance of multidisciplinary, collaborative teams in researching DBER and the need for interdisciplinary studies, including social sciences, that examine cross-cutting concepts and learning process and to measure or document a larger range of outcomes (beyond content knowledge, conceptual understanding and academic performance). Some of the expanded outcomes recommended include visualization competence, spatial thinking, engagement in real-world issues, and problem-solving, especially ill-defined problems that reflect many of those that are present contemporary society (NRC, 2012; Santos, 2012).

Potential significance

A Creative STEM approach will be key in providing a framework and tools to address complex contemporary and future societal problems. In the science teaching and learning field there has been a movement to reframe STEM as STEAM through the integration of the arts. This comes from the recognition that both scientists and artists use similar approaches to their work including drawing on curiosity, making careful observations, imagining and remaking the world (Sousa & Pilecki, 2013) and a call for obliterating disciplinary silos (Boy, 2013). In addition, research shows a positive correlation between participation in the arts and patents produced, citing that "artistic skills-such as analogies, playing, intuition and imagination" contribute to being able to solve complex problems (Parker, Roraback, & LaMore, 2013). In undergraduate STEM education, promising practices include developing visual competence, including the ability to critique, interpret, construct, and connect with physical systems and to find satisfaction engaging in science-based real-world issues (NRC, 2012). These are skills that that also intersect with arts-based practices (Root-Bernstien & Root-Bernstien, 2013) and it will be important (for me) to a research agenda around creativity to study how to meaningfully integrate the two.

Theoretical and methodological approaches

There are many definitions of creativity, but I am starting from a relational definition that describes creativity as a [product] of a confluence of multiple factors (Csikszentmihalyi, 2014); "a flow of affect between assembled bodies, things, and ideas" (p. 6) and that it is in the relations that creativity is produced "in the most unpredictable and unexpected ways" (p. 8). This perspective allows me, as a researcher, to examine and develop the contexts that allow creativity to flourish rather than how to design interventions that foster individual creativity. In the context of science, Sternberg (2003) asserts, "creativity can lead to new scientific findings, new movements in art, new inventions, and new societal programs" (p. 89), this is especially important in STEM where, as mentioned above, many issues are ill-defined and transdisciplinary (Santos, 2007; 2012). Central to my research will be refining definitions of creativity with a careful attention to what it means for STEM teaching, learning and research as well as equity and social justice in relation to STEM. Here, I will draw from a range of scholars, such as Sylvia Wynter and Katherine Mckittrick's whose notions of the relationship between science and creativity seeks to locate [scientific] knowledge-making as connected to the human lived experience and "the recoding of science through representational and biological feelings; the interdisciplinary and collaborative task that allows us to think about how the creative narrative can and does contribute to what is otherwise understood as 'the laws of nature…'" (McKittrick 2014 p. 154).

The Transformative Activist Stance of learning and development centers lived experience and posits that people learn and develop through both contributing to the social practices of a given community and by making unique contributions as they learn and transform those practices (Stetsenko, in press). This conceptualization of learning and development is a useful point of departure for defining Creative STEM it describes both creative development—the growth in creative capacity of an individual/collective over time and creative capacity—the level of complexity in which an individual/collective can engage in creative practices at a point in time (R. Kelly, personal communication, August 12, 2016). Translating research into practice is central to DBR (i.e. Barab, 2004) and central to this methodological approach is involving multiple stakeholders at all levels of the research. Primary approaches will be participatory, such as cogenerative dialogues conversations about "shared experiences of participating in a field" (Tobin & Roth 2006, p. 91), as a way of representing the perspectives of various stakeholders in the research and education process. Relational, dialogic approaches have been central to my research and will continue to be central as I move my research agenda forward. I plan to evolve and hone these practices to mirror the various learning contexts in which I research.

Major findings, conclusions, implications

As this is a new research project, there has not been any major findings to-date. However in an initial review of literature around creativity and STEM coupled with a transference of a decolonizing, transdisciplinary and justice-oriented stance towards STEM engagement and research, I expect to develop, research and describe new ways in and through STEM teaching and learning with creativity and possibly arts-based learning and research as an essential vein.

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Doctoral Consortium

CSCL 2017 Doctoral Consortium Workshop

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Introduction

The CSCL 2017 Doctoral Consortium Workshop, designed to support the growth of young talents in the field of the Learning Sciences, provides an opportunity for advanced Ph.D. students to share their dissertation research with their peers and a panel of faculty serving as mentors. Participants will engage in collaborative inquiry and scholarly discourse to improve and articulate their dissertation's contributions to the Learning Sciences and to advance their broader understanding of the field. To benefit from the Doctoral Consortium Workshop, applicants should be advanced graduate students, and be at a stage in their dissertation research where the participants and mentors may be of help in shaping and framing the research and analysis activities in respect to the larger field of Learning Sciences.

Objectives and design

- provide an opportunity for participants to reflect on their dissertation research and to highlight problems/issues for further discussion and inquiry that are of interest to the Learning Sciences;
- provide a setting for participants to contribute ideas as well as to receive feedback and guidance on their current research;
- provide a forum for discussing theoretical and methodological issues of central importance to the Learning Sciences;
- develop a supportive community of scholars in the Learning Sciences across countries and continents;
- collaborate and draw upon literature across countries and institutions;
- contribute to the conference experience of participating students through interaction with other participants and consortium faculty; and
- support young researchers in their effort to enter the Learning Sciences research community.

Doctoral Consortium Workshop activities are organized around small-group interactions. During the workshop, participants will first present their research briefly to familiarize each other with their dissertation project and highlight specific aspects they would like to have further discussion on. These may include specific problems for which the student is seeking advice; intriguing issues and tensions for research generally; methodological problems that other Ph.D. students are also likely to be confronting, or issues that have the potential of stimulating discussions of theoretical and methodological significance. Then, based on the common issues and themes identified (theoretical models, research design and questions, pedagogy and technology, data collection, methods of analysis etc.) participants will form small groups supported by expert mentors, to engage in further inquiry and discussion. Participants will work on the various problems and issues identified making reference to their own dissertation project and the broader field of the Learning Sciences. As well, they also have the opportunity to raise questions, provide suggestions, and help each other to improve their dissertation research. After the small group interactions, participants will report their progress and new questions to the whole group. Plans for further joint activity will be discussed as well.

Selection process

We received 27 applications from Asia, Europe, the USA and Australia and accepted 14. Every applicant was reviewed by two co-chairs. The criteria for acceptance included fit of the work to CSCL, quality of the work and the adviser's recommendation and, importantly, where they are in their research trajectory so that they could benefit from support to translate advanced dissertation work to the field of Learning Sciences.

Participants

Selected participants, their institution, country and title of their submission are below:

- Marielle Dado, University of Duisburg-Essen, Germany, Visualizing Networked Relations to Support Computer-Supported Collaborative Learning
- Catherine Dornfeld, University of Wisconsin – Madison, USA, Conceptualizing Scaffolding for Science Learning in Classrooms and Museums Using Mixed-Methods Approaches
- Xueqi FENG, The University of Hong Kong, China, Knowledge Building Discourse in a Large Community
- Helen Hong, National Institute of Education, Singapore, Teacher Leadership in Information and Communications Reform
- Dima Kassab, University at Albany, State University of New York, USA, The Effect of Playing Portal 2 on Collaborative Problem Solving
- Derya Kici, Ontario Institute for Studies in Education, Canada, Evolution of Knowledge Building Teacher Professional Development Communities
- Alwyn Vwen Yen Lee, Nanyang Technological University, Singapore, Idea Identification and Analysis (I2A) for Sustained Idea Improvement in Knowledge Building Discourse
- Elizabeth McBride, UC Berkeley, USA, Connecting Science and Engineering Practices: Using Models to Improve Student Understanding of Energy Transformation
- Amanda Siebert-Evenstone, University of Wisconsin – Madison, USA, The role of context in virtual environments: Investigating student reasoning with online places
- Dan Tao, University at Albany, State University of New York, USA, Fostering sustained knowledge building practices in Grade 5 science: A reflective structuration approach
- Jennifer Tsan, North Carolina State University, USA, Toward Adaptive Collaborative Support for Elementary Students Learning Computer Science
- Robert Wallon, University of Illinois at Urbana-Champaign, USA, Embodied Learning with Gesture Augmented Computer Simulations in Middle School Science Classrooms
- Xu Wang, Carnegie Mellon University, USA, Public Peer Review for Collaborative Learning in MOOCs
- Shulong Yan, The Pennsylvania State University, USA, Understand Group's Learning from Productive failure in Design Context: A Collaborative Failure Management Learning Model

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Connecting Science and Engineering Practices: Using Collaborative Annotation to Improve Student Design Justifications

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Research goals

To help students acquire the science and engineering practices called for by the NGSS, this research investigates ways to optimize science outcomes from a collaborative design project. I seek ways to support groups of 2-3 students working together on a design project. Students draw on their scientific ideas about energy and energy transformation as they collaboratively design, build, and test a solar oven. Through prior research, I have refined the curriculum, which uses an online platform to guide students through the process and an interactive computer model where students compare designs for a solar oven. This fall, over 700 students in 5 classes used the refined curriculum. Preliminary results reveal the need to redesign the supports for collaborative design in order to improve learning outcomes and to capture the insightful conversations students engage in during the curriculum.

Project background and framework

Students often neglect scientific principles when designing hands-on solutions (Crismond, 2001). To address this challenge, I designed a computer model to help students connect science principles to their design decisions by making mechanisms such as energy transformation visible (Wilensky & Reisman, 2006). This research explores the effectiveness of the model, including what scaffolding is necessary to encourage collaborative use of the model.

To strengthen connections between the model and the hands-on activities, I used the knowledge integration framework to guide the curriculum design (Linn & Eylon, 2011). The framework emphasizes connecting design decisions and scientific principles by eliciting all the ideas students think are important, then engaging them in distinguishing and refining their ideas. The knowledge integration framework has proven useful for design of instruction featuring collaborative activity and virtual design activities (Chiu & Linn, 2011; McElhaney & Linn, 2011). When students build a physical artifact they can often only test a few of their ideas due to time and material constraints; using the interactive model allows students to explore many more ideas.

Combining engineering design with knowledge integration, I guided students to iteratively design, build, and test their solar ovens. Students improved their ovens by collaboratively analyzing their tests and using the results to inform the next iteration of their design. They used the interactive model to analyze their tests and jointly explore alternative design decisions. The model helps students visualize the energy concepts involved in the design (Figure 1). It displays the results for each design in a temperature graph, a valuable method for capturing unobservable processes. The computer model plays an important role in linking science concepts with the design process because students are able to manipulate design alternatives while seeing how their choices impact energy flow.

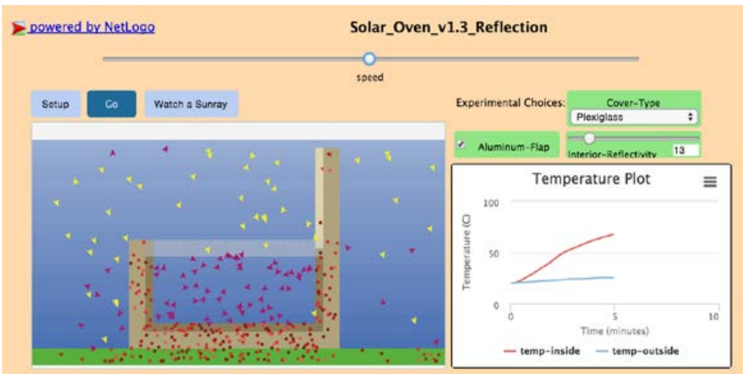

Figure 1. Screenshot of solar oven model.

Methodology and preliminary results

In these studies students always collaborate with a partner. Embedded assessments allowed me to track the progress of the collaborative pair and demonstrate the impact of the curriculum (McBride et al., 2016). During the fall of 2016, 5 teachers implemented the solar ovens curriculum in their classrooms (~700 students). In each classroom, students used an online project report that is built into the curriculum. In this space, students documented how they designed, built, and tested their oven. Analysis of the data showed that the model impacted learning and aided pairs in differentiating between concepts. However, classroom observations revealed that the open-ended project report did not adequately capture students' rich decision making. An earlier version of the project report scaffolded student entries after each design activity (design, build, or test), limiting connections across activities. I am planning a study this spring to further refine the collaborative report.

Based on over 500 hours of classroom observations of the solar ovens curriculum, I will refine the project report to encourage collaboration and document collaborative design ideas. I will test the impact of this refinement in a comparison study in at least two classrooms during March and April 2017. Specifically, I will strengthen the possibility of capturing the insightful discussions students have about how their oven is working and what they want to change about it during the testing phase. Students will take a picture of their oven before testing it and record their ideas during the testing period. During testing, students will annotate the picture of their oven while observing it under the sun lamp for 10 minutes. Based on recent research findings and classroom observations I will compare instructions to *explain or critique* the oven (Chang & Linn, 2015; McBride et al, 2017). I have observed productive discussions in which students worked on a collaborative explanation for how their oven worked and others where students critiqued their oven in preparation for the redesign phase. To determine the advantages of these activities, I will randomly assign collaborative groups to *explaining* or *critiquing* during testing. Students in the *explain* condition will be asked to annotate how each feature of their oven is functioning. Students in the *critique* condition will be asked to assess the limitations of their design. I will analyze the annotated images and the impact of the two conditions on student learning.

Further issues to explore

Next steps include improving the scaffolding during the hands-on phase of the curriculum, strengthening methods for assessing collaboration, and improving the efficiency of capturing student interactions in the noisy, crowded classrooms where this research takes place.

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Idea Identification and Analysis (I^2A) for Sustained Idea Improvement in Knowledge Building Discourse

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Abstract: Understanding ideas in discourse is a challenge, especially through textual discourse analysis. My goal is to identify promising ideas that can sustain idea improvement in knowledge building discourse, and to investigate the effect and impact on collective advancement of communal knowledge. This study encompasses the design and development of a new methodology Idea Identification and Analysis (I^2A), which uses network analysis and temporal analytics to recognize idea types and attributes of promising ideas. This method is also applicable to other forms of collaborative discourse.

Research goals

My research aims at developing and testing a new methodology called Idea Identification and Analysis (I^2A), which identifies and analyses promising ideas not apparent to learners in a knowledge building discourse, and explores the attributes of these promising ideas. This methodology involves analysis of the learning processes, discourse units and epistemic keywords. This study can contribute to the broader goals of knowledge building pedagogy, which leverages learner's natural idea generation capability to achieve collaborative improvement of collective knowledge artifacts; the methodology also provides information that helps teachers maintain student engagement in the process of building on and sharing of ideas in discourse.

Background

Knowledge creation as a learning approach was advocated to develop learners' 21st century competencies. Knowledge building was introduced as a process of creating and improving ideas within a community as part of the broader cultural effort, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions (Scardamalia & Bereiter, 2006). By engaging in collaborative knowledge building discourse, learners engage in social collaborative inquiries to contribute and advance communal knowledge. The initial stage of discourse often leads to diverse perspectives, and practical constraints of curriculum time prevents the pursuit and improvement of all ideas discussed. It is thus critical to identify ideas that are promising to the collective advancement of communal knowledge. However, identifying promising ideas that are communally relevant and interesting is, by itself, a laborious process. To resolve this issue, existing platforms and tools were constructed and harnessed in different approaches for analyzing knowledge building discourse. These tools include Knowledge Building Discourse Explorer (KBDeX; Oshima, Oshima & Matsuzawa, 2012) that uses social network analysis (SNA) for discourse analysis; Idea Thread Mapper tool (Zhang, Chen, Tao, Naqvi & Peebles, 2014) that supports collaborative reflection for sustained knowledge building; and Promising Ideas tool (Chen, Scardamalia & Bereiter, 2015) that allows students to identify and highlight promising ideas manually. Further research is needed to accelerate and possibly automate the process of finding and understanding the impact of promising ideas on knowledge building discourse. The effort required to support sustained creative efforts at idea improvement is a principal challenge (Scardamalia, 2014) and has garnered attention among researchers, especially with the advent of learning analytics that may uncover new learning patterns and behaviours from knowledge building discourse. By developing a methodology to identify and analyze promising ideas in the knowledge building discourse, insights may be uncovered with deeper understanding of these promising ideas, and more resources can be devoted to sustaining community interest in improving promising ideas within discourse.

Methodology

The I^2A method (Lee, Tan & Chee, 2016) was developed to identify and analyze promising ideas that will influence learning, using a mixed method approach. A pilot study was conducted with a student community in Singapore, using an online knowledge building environment called Knowledge Forum (Scardamalia & Bereiter, 2006). Twenty eighth-graders were taught the science topic of "Human Transport System" over two weeks. The experienced middle school science teacher had prior knowledge building experience and previously used physical "idea cards" to trigger interactions and present authentic problems. Students were keen to discuss and share their ideas using Knowledge Forum, as they found that the social interactions could help advance communal knowledge. Each student was provided with a booklet on a fictional character "Uncle Yong", who has an impending heart attack. This issue was authentic to some students, whose family members had heart diseases, and acted as a trigger aimed at eliciting students' ideas and discussions about cardiac problems. Thought-invoking questions and responses were shared on a central view in Knowledge Forum. At the end of the learning session, the textual discourse of students was extracted and keywords representative of ideas were identified from discourse, either through text mining or by the teacher. Bipartite graphs were constructed using KBDeX to discover relationships between the students, discourse units and keywords. Network analysis was used to calculate the betweenness centrality, a quantitative network measure that is used to identify promising ideas. My interpretation of the betweenness centrality coefficient can be viewed as the degree of importance of ideas to multiple discourse stakeholders at different temporal junctures of the discourse, and how well ideas in certain discourse units help mediate and sustain interests in other ideas, such that the community can continuously improve promising ideas over the period of discourse. Qualitative analysis was conducted to validate the promising ideas and the impact on knowledge building discourse.

Pilot results and issues to discuss

An analysis of the pilot study was presented at ICLS 2016. I argued that by shifting analyses away from the student social interaction network to the idea network of discourse units, the attributes of promising ideas and degree of promise can be assessed, using SNA and the network measure betweenness centrality. Using an analysis of betweenness centrality trends over the period of discourse, the I^2A methodology was able to classify four kinds of ideas found within students' notes and determined promising ideas that were impactful to the community discourse. Quantitative findings in the pilot study suggest that by identifying occurrences of promising ideas and improvements brought about by different discourse units, the flow and content of ideas are predicted to enhance over the discourse. The findings were then qualitatively validated.

To date, this research demonstrates the potential for automated tagging of promising ideas and understanding of the subsequent impact of promising ideas on communal discourse. The I^2A methodology allows students and teachers to focus more on improving identified promising ideas beyond the current status quo. Members in a community could focus on advancing their understanding, rather than spend time trying to identify possible relevant and promising ideas from a large pool of ideas. Although the I^2A work in my dissertation is currently implemented in on-going studies, I will like to investigate further the challenge and other possible methods in maintaining students' engagement for idea development and improvement in knowledge building discourses across different levels of education. Other network measures such as degree centrality are also being considered. This work has been extended with some success in integrating temporal analytics (Lee & Tan, 2017), with an eventual goal of integrating machine learning into discourse analysis, to conduct step-wise discourse analysis for tracing and understanding the nature of promising ideas, and determine further the impact of promising ideas on communal discourse.

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Public Peer Review for Collaborative Learning in MOOCs

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Peer review has been widely used in MOOCs, in which context it's almost impossible for one instructor to grade and provide feedback to all students' assignments. However, current peer review systems are mainly private and designed for the purpose of course administration, while the value of feedback for students is less explored. The fact that feedback quality drops quickly and that there is a lack of diversity and reciprocity in feedback remain big issues. In my thesis, I will explore ways to address this problem, with a goal to increase the quality of peer feedback in MOOCs and evaluate the benefit of peer feedback for learners. Contextual in MOOCs, I propose a new ecosystem of public peer feedback. In my work, I will start by building a public peer review system—PeerLearn, in which all students' assignments and feedback are visible to each other. In the system, we will apply machine learning techniques to direct students to useful information that they may not have access to in a private peer review system. I will continue to explore ways to scaffold students to provide higher quality feedback. The learning facilitated by the system is twofold: on the one hand, students will benefit from receiving new insights and strategies from different pieces of feedback; on the other hand, we aim to help students calibrate the ways and perspectives they provide feedback, thus improving their abilities to critique their own and each other's work. I envision the public peer review system and our subsequent studies on what interventions would help with learning and increased feedback quality will lead to a framework about a new generation of peer assessment in MOOCs.

Background and preliminary work

Massive Open Online Courses (MOOCs) show promise of delivering high-quality education resources to a large number of audiences. While online courses may be able to deliver the exact same learning materials as a professor uses in class, e.g., lecture videos, quizzes, etc., it's really hard to simulate the interactive learning experience one may have in a real class, for example, the opportunities to interact with instructors and discuss and get feedback from classmates. Due to the usual large size of MOOCs, it becomes unrealistic for the instructor to respond and provide feedback to each student's work. On the other hand, this also offers great potential to take advantage of the wisdom of the crowd to satisfy learners with their information and learning needs through better structured peer interaction and peer feedback.

In my previous work, I investigated how discussion behaviors in MOOC forums affected learning. In Wang et al. (2015) and Wang et al. (2016), we developed a coding manual based on the ICAP (Chi & Wylie, 2014) framework to code different discussion behaviors in MOOC discussion forums. We found that students who have displayed higher-order thinking behaviors in MOOC forums learnt more throughout the course. This motivated our design to facilitate higher quality discussion in MOOCs. We also used machine learning approaches to model different categories of discussion behaviors, which built foundation of my current work to automatically detect different characteristics of feedback.

Following analyses of discussion behaviors, I continued to explore ways to support discussion for learning in MOOCs. I was involved in the project (Wen et al., 2016) where a group formation method was developed to assign students to groups based on whom they have talked to the most transactively. Later, I developed an intervention (Wang et al., 2017) using scaffolded prompt to support small group discussion in MOOCs, with the goal of encouraging learners to disclose information and compare ideas from different perspectives. In Wen et al. (2016), we found that students benefited more when they received feedback from the whole class compared to receiving feedback from a smaller group. In Wang, et al. (2017), we found that the explicit scaffolding in group conversations helped with students' multi-perspective knowledge acquisition. This motivated our design to expose students to more feedback and feedback from different perspectives.

My previous work inspired and laid foundation for my current focus to better structure peer feedback in MOOCs. From a theoretical perspective, I see gaps between principles and theories in the CSCL literature and current practice in MOOCs. One general trend we found in the literature of peer assessment in MOOCs is a focus on getting an accurate grade to students. (e.g., Sajjasi et al., 2016; Staubitz et al., 2016) The value of feedback in terms of learning benefit is less discussed, as to how to take advantage of the massive audience to enable more helpful and comprehensive feedback for learners to improve. I aim to synthesize the two bodies of literature, and contribute to the CSCL literature by investigating what the new affordances in MOOCs could tell us about feedback and collaborative learning that we are not able to observe in traditional education systems. From a practical perspective, I aim to implement the insights and design ideas I learnt from my previous work to foster better peer review practice in MOOCs, including techniques to model discussion behaviors, and design recommendations to provide scaffolds in conversations, increase multi-perspective interaction, and expose students to higher quantity and quality of information. Furthermore, peer review is a learning activity that is already embedded in a lot of MOOCs, which shows promise for large-scale deployment. I also aim to contribute to the CSCL field by applying CSCL principles to provide better learning experiences at scale.

Methods and plans

In my thesis, I will take an empirical and experimental methodology, with both lab studies and later deployment studies in real MOOCs.

We are currently in the process of developing the public peer review system. The system will have, but not limited to the following features: 1) Students will have the autonomy to choose whether their assignments and reviews are displayed to the public. 2) Students will be able to read all assignments and feedback under disclosure. 3) Students are able to back review the feedback they receive. 4) All feedback in the system are automatically labeled with the characteristics in our coding scheme using machine learning techniques, e.g., whether there is a problem or a solution in the feedback. 5) Students are given the choice to filter through different types of information, e.g., similar to what we usually see in a product review model: "students who have similar problems as you find the following comments helpful", "students who are most like you wrote the following comments", etc.

My hypotheses about the interventions mentioned above include but not limited to, 1) Students will get better at providing feedback when prompted to see feedback from different perspectives. 2) Students will benefit from reading feedback targeted at the same problem they had in their own assignments. 3) Students are more interested in reading feedback from students who are like them. 4) Students will benefit more from reading feedback written by students who are unlike them. 5) The public peer review approach increases reciprocity of feedback. 6) The public peer review approach increases quality of feedback.

In addition to the passive information filtering interventions that allow students to access information of higher quality and relevance, we seek to provide active support and scaffolding when some of the hypotheses are confirmed or disconfirmed. For example, if we found students benefit more from reviewers who were unlike them, we can apply machine learning techniques to match students using this rule. We also see possibility of prompting reviewers to look for particular things when providing feedback. For example, if my weakness were in logic, my reviewers would be prompted to emphasize their feedback on logic for me.

I plan to conduct a series of lab and deployment studies to investigate the learning benefit of different interventions. The results from the studies will inform us about how effective public peer review is, what makes it beneficial, and what are the ways to make it better. I envision this work will lead to a framework about a new generation of peer assessment in MOOCs.

I think the CSCL doctoral consortium is a great place for me to share, discuss and further my research ideas with researchers in the field. It will be especially helpful for me to learn others' experiences and perspectives about peer review, and I anticipate the discussion at the consortium will help me improve the system, extend the questions I could ask about peer review, and be aware of potential drawbacks.

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Embodied Learning With Gesture Augmented Computer Simulations in Middle School Science Classrooms

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Goals of the research

In my research I seek to understand the use of mixed reality simulations that cue gestures (MRSCG) in middle school science classrooms. This broad topic includes three main strands:

(a) *Learning*. What are the individual learning outcomes that result from using MRSCG? How does the collaborative use of GACS mediate this individual knowledge construction?

(b) *Design*. What scaffolds support collaboration with MRSCG, with specific focus on promoting joint attention, co-construction of knowledge, and convergent conceptual change?

(c) *Perceptions*. What are teacher and student perceptions of learning processes and outcomes of using MRSCG?

Background of the research

My work branches out from a larger NSF-supported project based at the University of Illinois called GestuRe Augmented Simulations for supporting exPlanations (GRASP; http://grasp.education.illinois.edu). The overarching goal of the GRASP project is the design of computer simulations that support students with explaining science concepts that research has shown to be persistently challenging. Now in the third year of the project, the main data source for GRASP has been interviews in which individual students use simulations while being supported by a member of the research team. Preliminary findings from the project have shown that these learning environments have been successful for helping students develop more sophisticated explanations that are more in line with canonical scientific explanations of target phenomena. Based on my experience as a former science teacher, I became deeply interested in studying the extent to which these types of learning environments could support these outcomes in classroom settings. And if they could support these learning outcomes to a great extent, I wondered, what processes would mediate those outcomes? Consistent with the learning sciences commitment to research in authentic settings, I have started to design my dissertation research around these issues.

I view my research as concerning the intersection of constructivism and embodied cognition. In science education, constructivism provides individual and social accounts of knowledge building processes (Driver, Asoko, Leach, Scott, & Mortimer, 1994). As embodied learning has become an area of growing interest (Lindgren & Johnson-Glenberg, 2013), researchers have started to explore social dimensions of embodiment (e.g., Enyedy, Danish, & DeLiema, 2015), in an area that has traditionally emphasized individual dimensions. My dissertation study seeks to further explore synergies and tensions between constructivism and embodied cognition, especially as they relate to social dimensions of embodied learning.

Methodology

While my research is designed primarily within an interpretivist paradigm, I use a mixed methods approach to address my research questions. Because my research questions concern learning outcomes and learning processes, a nested mixed methods design (Greene, 2007) is appropriate for the purposes of complementarity and initiation (i.e., to provide a broader understanding of learning and to seek out possible contradictions). For example, my examination of student learning outcomes will include analysis of written student work and focused interviews with a subset of students. Analysis of student work will provide a broad picture of student learning outcomes, and interviews with students will allow for deeper interpretations of student learning. These methods will be mixed at the level of analysis, and they have the potential to reveal divergences such as possible instances when students may show evidence of extensive learning by using one method, while they may show little evidence of learning by using another method.

Current status and results of pilot work

The timeline for my project involves collecting data from classrooms during the 2017-2018 school year. Below I share highlights from my pilot work.

My first pilot study took place in three periods of an eighth grade classroom during an astronomy unit. Students used the seasons simulation. Some of this work has been accepted to be presented in a poster at the 2017 CSCL conference. From my first pilot study I learned:

- An optimal arrangement for collaboration with MRSCG seems to be two rather than three students.
- Cued gestures can serve as objects of joint attention for groups of students working with MRSCG and thus have potential to support collaboration.
- Additional elements need to be designed to support co-construction of knowledge, positive interdependence, and convergent conceptual change
- Different assessments of individual student learning revealed important differences in students' explanations of scientific phenomena. Specifically, students who did not draw light rays in their models of seasons included light rays during focused interviews.
- Students appropriated gestures cued by the computer simulations in their individual explanations (see Figure 1) several days after using the simulations.

Figure 1. Gestures for elaborating on the role of light rays used by three students.

My second pilot study took place in four periods of a different eighth grade classroom during a unit on matter. Students used simulations on gas pressure and heat transfer. Noteworthy findings from this pilot work focus on teacher perceptions of the simulations. The teacher was particularly impressed with how diverse students were engaged by the simulations. She reported that some of her ELL students showed high motivation by using an online translator to write their explanations in English. She also reported that some of her students with special education needs showed high levels of autonomy, motivation, and understanding while using the simulations.

My third pilot study took place in four periods of a sixth grade classroom during an astronomy unit. Students used the seasons simulation. This pilot work was completed recently and thus more thorough analyses have yet to be performed. However, it is noteworthy that debrief discussions in four class periods provided preliminary data about student perceptions of MRSCG. Interestingly, students had divergent perceptions of how helpful cued gestures were for their learning, with some students strongly in favor and some students strongly opposed to the utility of interacting with the simulations with gestures.

Issues to be explored at the workshop

There are two main issues that would be valuable for me to explore at the doctoral consortium: (a) how to design additional scaffolds to support collaboration while students use GACS, and (b) how to measure collaboration broadly in a classroom setting. The first issue was made salient by my pilot work when it became clear that collaborative use of the simulations was helpful but was not consistently happening. The second issue comes from some technical limitations that I have experienced in that I have been able to video record only one or two groups of students within each whole classes. While analysis of the video data provides a rich source for characterizing collaboration of those groups, I am also interested in broader measures of collaboration of all groups in a classroom.

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Toward Adaptive Collaborative Support for Elementary Students Learning Computer Science

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Abstract: Collaboration is an important aspect of learning. For computer science, pair programming has been shown especially beneficial. I have begun to study pair programming dialogue with elementary school students engaged in block-based programming. My preliminary results show that students can struggle to engage in balanced collaborations. This problem is in part due to difficulty sharing the controls, a lack of understanding of pair programming roles, and the need to build good collaborative dialogue practices. For my dissertation, I propose to develop and iteratively refine a collaborative block-based programming environment to support real-time collaboration for young students.

Keywords: K-12, pair programming, real-time collaboration

Goals of research

The goal of this research is to gain insight into how young children pair program and how we can better support them. Pair programming is a method in which two programmers work side by side, usually at the same computer, each fulfilling a role and switching roles after a specified amount of time or after a task is complete. Research has been conducted regarding what features should be included in a collaborative environment (Guzdial, Hmelo, et. al., 1997), the effectiveness of collaborative feedback on collaborative behavior (Zumbach, Schönemann, & Reimann, 2005), and how to evaluate collaborative learning processes (Hmelo-Silver, Chernobilsky, & Jordan, 2008). However, research in collaborative programming environments for young children is just emerging (Al-Jarrah & Pontelli, 2014).

Research questions

My overarching research question is, *How can we improve current programming environments to adaptively support elementary students in pair programming?* To investigate that question I will also address the question, *How can we build adaptive programming environments to support good collaborative dialogue practices?*

Current status and preliminary results

I collected data from a computer science elective classroom in an elementary school, including videos of students pair programming. Research questions I have started to investigate are: *How do young coders balance their dialogue, turn-taking and control during collaborative computer science learning?*; and *How do young learners coordinate their dialogue during collaboration for computer science?* I found that elementary students are often unbalanced in terms of how much they speak, drive, and contribute ideas to the project. The imbalance in the pair programming relationships may be due to students having difficulty understanding their roles and not knowing good dialogue practices for collaboration. Therefore, to support the students, we should teach them good pair programming and collaborative dialogue skills. These skills include: staying active in either role, with both students contributing throughout the process and the navigator asking more questions; sharing not only the keyboard and mouse, but also the responsibilities of their roles; and building upon each other's ideas.

Plan

After identifying problems and potential support points for young students pair programming, I would like to modify existing programming environments such as Scratch, a popular block-based programming environment that encourages collaboration (Maloney, Resnick, et. al., 2010), to better support children's pair programming process. I specifically plan to help students to share and stay active in their roles, building on prior work on equity of pairs in terms of dialogue and physical controls (Shah, Lewis, & Caires, 2014; Deitric, Shapiro, & Gravel, 2016). I will modify the environment to allow multiple students to login using different computers to view and work on the same project on separate computers while collaborating remotely or in person. I will consider several design decisions based on user studies and iterative refinement, as well as a literature review of existing collaborative tools for young children and broader audiences. These design considerations include:

- How should the synchronized collaborative support be designed?
    - Should both students be able to edit at the same time, similar to how collaborators can work in Google docs?
    - Should the interface be limited to only person editing at once? The work will synchronize and both partners will be able to see the changes and they can switch controls at any time, but the partner who is not editing cannot make changes.
    - Should the interface be limited to only the driver editing? The work will synchronize and both partners can see the changes. The software could support the students switching roles, and the current driver would be the only one that can make edits.
- What types of messages should be delivered, and when, to support effective collaboration for computer science problem solving?

Issues and problems for further discussion
At the doctoral consortium, I would like to receive feedback on my research plan. After a literature review and initial pilot, I plan to iteratively test and refine the software. For the studies, I will recruit elementary students who are participants of clubs or classes that involve programming, technology, or computer science. The students will be given one hour of instruction on the coding environment, take individual pre-tests, and then they will pair program to solve a problem using the modified version of the coding environment. Afterwards, they will take individual post-tests and surveys, then I will hold 30-minute focus groups to obtain feedback on how well the software ran and supported the pair programming process. Then studies will have two conditions: students pair programming on one computer using the original coding environment; and students pair programming on two computers using the modified coding environment. These conditions will help me determine the ways in which the features I add support student collaboration.

After each study, I will analyze the students' dialogue and actions to determine whether students in the experiment condition used better collaborative dialogue practices and fulfilled each role better. In addition, I will calculate the students' learning gains to determine whether students in a specific condition benefited more from their collaboration. Between each study, I will refine the software based on the findings from the data.

Expected contributions
By the end of my dissertation I would like to have contributed methods and a tool to further support young students collaboratively solving programming problems. I hope my work will enlighten the community on how we can better support collaboration between young students in the future.

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Knowledge Building Discourse in a Large Community

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Abstract: Knowledge building is an inquiry-based educational model that emphasizes knowledge creation and theory building. Most research on knowledge building has focused on small classes of 20 to 30 students. In many Asian countries, including China, classes are much larger, typically 50 to 60 students. Little is known about how to orchestrate knowledge building in such settings or about issues of scale in its online discourse. My dissertation investigates this problem via design research in which I design, implement and evaluate a knowledge building environment to advance knowledge building discourse in multiple classes of approximately 50 students.

Background

China is committed to modernizing in education and is open to the Western pedagogical approaches that have been developed in the learning sciences (Ryan, 2013), but the small classes of the West are not currently feasible; and the knowledge building model also envisages communities that are larger than Western classes (Scardamalia & Bereiter, 1996). It therefore is important to understand how knowledge building works on larger scales. Primarily, communities have been bigger than about 20, teachers have subdivided them on to groups(Niu & van Aalst, 2009), but this was found to reduce interactivity and the diffusion of new insights. Zhang, Scardamalia, Reeve, and Messina (2009) studied knowledge building using three different social configurations and found that not assigning students to groups was best on all variables they analyzed. However, it is not known whether such findings scale and whether they can be confirmed in a cultural context that is much more examination-driven, even in primary school.

Methodology

My dissertation involves a preliminary analysis and two cycles of design research.

Preliminary analysis

This phase aimed to explore the pedagogical design for large class. 51 students from one fourth-grade class were asked to write questions about Sound in papers individually. The questions were found to be primarily explanation-seeking ones (van Aalst, 2009), but with high repetition rates. Network analysis with the Knowledge Building Discourse Explorer (Oshima, Oshima, & Matsuzawa, 2012) to explore the students, words and discourse networks in a small-group structure in an existing database on Knowledge Forum (KF) suggested that the pedagogical design of Study 1 should focus on promising ideas and adopt exploratory discussions in face-to-face mode in small groups before writing on KF in larger communities.

Study 1

Study 1 aimed at fostering knowledge building culture for large classes.

Participants

Four 4th graders (about 50 students for each) from a primary school in mainland China participated in the study. Students studied Sound over ten weeks. Two classes shared the same knowledge building community, and the other two classes used their own community on KF for practical reasons. The researcher on leave from the school as a science teacher but returned to teach all 200 students.

Pedagogical design

The researcher tried to build the knowledge building culture through a series of topics as follows: what scientists do; notion of promising ideas; promising ideas relating to sound; knowledge building; inquiry learning on sound in small groups, expert lecture on sound; writing on KF; how to improve knowledge building discourse; and deepening knowledge building discourse.

Data sources and data analysis

Extensive data were collected from this unit, which lasted 10 weeks. Data analysis will focus on the characteristics of knowledge building in large community. All these data have been processed (e.g., transcribed) and are currently being analyzed. The analysis is being framed using the design conjecture and theoretical conjecture mappings of Sandoval (2014).

Study 2

The results from Study 1 will inform the design of Study 2, with possible revision of the conjectures of Study 1. At the same time, while study 1 focuses much on the pedagogical details, study 2 will also provide a deeper analysis of the KF database. For this I will use analytical methods that have been used extensively in knowledge building research, including network analysis (Oshima et al., 2012) and qualitative analyses used in smaller datasets, including the analysis of discourse in inquiry thread.

Current status

By the time of the conference I can present early results from study 1 and receive feedback that will enable me to refine the design of study 2 before I begin data collection in October 2017.

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Fostering Sustained Knowledge Building Practices in Grade 5 Science: A Reflective Structuration Approach

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Abstract: The key to understanding how knowledge building as a social practice can be possibly sustained lies in the dynamic relationship between agency and social structures that presuppose each other. My dissertation contributes to a dynamic approach to inquiry-based knowledge practices, reflective structuration, aiming to investigate the critical social structures that emerge from dynamic knowledge building interactions, the mechanism behind social structures emergence, as well as how these findings can be used to support sustained and productive knowledge building practices. Initial analyses of data revealed that in productive knowledge building communities, members not only build collective knowledge, but co-construct adaptive collective structures which provide members with shared expansive frames of their collective work to pursue deep research and collaboration.

Keywords: knowledge building, science inquiry, reflective structuration

Introduction

Though extensive studies have examined the social and cognitive processes of inquiry-based learning and knowledge building as well as teacher and technological scaffolding to support these processes (Bell et al., 2010; Hmelo-Silver et al., 2007; Reiser, 2004), the field of computer-supported collaborative learning (CSCL) still faces the challenge of how to engage students in authentic, coherent problem solving and develop real ideas over longer periods of time (cf. NRC, 2012; Stahl & Hesse, 2009). Knowledge Building (Scardamalia & Bereiter, 2006), a renowned inquiry-based program to cultivate authentic knowledge-creating practices, adopts an idea-centered and principle-based approach to classroom designs. Guided by a set of knowledge building principles (Scardamalia, 2002; Zhang et al., 2011), students and their teachers co-construct and reconstruct the flow of inquiry as their work proceeds. A conceptual as well as practical challenge arises pertaining to how the idea-centered actions/interactions are translated into coherent, supportive, long-term classroom practices without extensive teacher pre-scripting.

Research goals

The key to understanding how knowledge building as a social practice can be possibly sustained lies in the dynamic relationship between agency and social structures that presuppose each other (Giddens, 1984; Sewell, 1992). My research contributes to a dynamic approach to inquiry-based knowledge practices, ***reflective structuration***, aiming to investigate the critical social structures that emerge from dynamic knowledge building interactions, the mechanism behind social structures emergence, as well as how these findings can be used to support sustained and productive knowledge building practices. Specifically, my research addresses the following questions: What collective structures are developed by knowledge building communities to support sustained inquiry? How do collective structures emerge from knowledge building interactions and further evolve to sustain knowledge building practices as a long-term initiative? How can a knowledge building community plan and implement a whole school year's inquiry based upon the reflective structuration framework? Does the systematic structuration design leverage the productivity of knowledge building? To what extent? And in what ways?

Methodology

This two-phase exploratory sequential design (Creswell & Clark, 2011) was implemented in four Grade 5 classrooms (about 20 students per class) taught by two teachers, teacher A, and teacher B from 2013 to 2016 (see Figure 1). All four classrooms investigated the human body across the whole school year using Knowledge Forum (Scardamalia & Bereiter, 2006), an online collaborative knowledge-building environment. The first phase of the research is composed of two case studies with teacher A (case 1 in 2013-2014 and case 2 in 2014-2015), to explore different collective structures that emerge from knowledge building interactions over the school year, and the dynamic processes by which these structures of inquiry are co-generated, adapted, and revisited by the communities. Findings from these two exploratory cases lead to a two-year design-based research with teacher B (in 2014-2016) to systematic implement the framework with a different teacher and test its impacts. Data collected in these studies involve field notes recording the knowledge building activities, classroom videos, pictures of students' notebooks, pictures of classroom artifacts, students and teachers interviews, teacher's reflection journals, students' knowledge building discourse in KF.

Empirical studies

Results from an initial pass of analyses of the two cases are very promising. My first case study explored the metacognitive processes by which a Grade 5 class co-framing a list of shared deepening goals to direct its inquiry about human body across a whole school year. Analyses of rich classroom data revealed that the collective goals emerged and evolved through several reflective cycles: formulating an initial list of big "juicy" questions based on diverse individual interests and questions, expanding the list to include questions about digestive systems and vocal cords based on individual and collaborative proposes, reframing existing goals in reflection of new emergent issues, and developing new conceptual goals at the intersection of different lines of work focusing on deep concepts identified. My second case study examined how a Grade 5 knowledge building community worked together to co-generate a collective structure in the form of "research cycles" and used the structure adaptively to sustain productive knowledge building over a school year. The emergence of the research cycles underwent several iterative cycles of reflective talks: Students reflected on their individual research journey and identify the key moves they made to conduct inquiry; Students reflected on their ways of inquiry in small groups to co-generate a small group research cycle to guide collaborative inquiry; Based on their trial of their research cycles, students then reconvened as a whole community to generate a collective model of research cycles, as a structure-bearing artifact.

Consortium focus

Results from previous studies listed above are very promising. However, I'm facing great methodology challenge in analyzing a tremendous amount of qualitative data collected in the four classrooms. At the time of the consortium, I will have completed a comprehensive analysis of data for the two cases and will begin to frame the two-year design based research for deeper analysis. I would greatly benefit from the DC's expertise to further refine my research design (DBR) and classroom qualitative data analysis (both f2f and online) that could perfectly capture the socio-epistemic mechanism across different time scales.

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Visualizing Networked Relations to Support Computer-Supported Collaborative Learning

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Abstract: One way of fostering collaborative learning in CSCL environments is through representational tools that visualize key social and cognitive information to help learners establish common ground. Through a series of empirical studies, this PhD thesis project aims to evaluate the effects of network visualizations of different relational structures as representational guidance to support learning outcomes and processes in CSCL environments. Social network analysis is applied to uncover relational structures of collaborative learning activities, which are then presented as network graphs to learners in experimental and authentic learning settings. This project specifically focuses on visualizing mediated relationships between learners via artefacts as well as relations between artefacts in the learning environment.

Keywords: collaborative writing, wikis, social network analysis

Background and goals

CSCL can be described as a form of networked learning, given that CSCL relations are distributed across actors, time, space, and media (Jones, 2007). These relations may be established synchronously or asynchronously, may be direct relations between learners, or be mediated by artifacts. One way of fostering collaborative learning in CSCL environments is through representational tools, such as knowledge mapping tools (Suthers, Vatrapu, Medina, Joseph, & Dwyer, 2008) and group awareness tools (Bodemer & Dehler, 2011), that visualize key social and cognitive information to help learners establish common ground.

The overall aim of this PhD project is to contribute to the literature on representational tools in CSCL environments by incorporating visual representations that convey networked relations between learners. Social network analysis (SNA), a method for representing relational structures in online environments, is applied to reveal relational structures of collaborative learning activities. In a series of empirical studies, SNA network graphs are presented to learners to study whether awareness of various relational structures help improve learning processes and outcomes. To identify specific research gaps, a methodological review of 90 CSCL studies that apply SNA was conducted. Network text analysis followed by bipartite modularity maximization on prominent CSCL and SNA terms from the studies revealed a "conceptual core" of CSCL communication elements (e.g., "forum", "post") and the basic SNA indices (Dado, Hecking, Bodemer & Hoppe, 2017). Considering these results, this PhD project focuses on visualizing *mediated relationships* between learners via artefacts as well as *relations between artefacts* in the learning environment as support mechanisms for learning processes and outcomes in CSCL.

First study

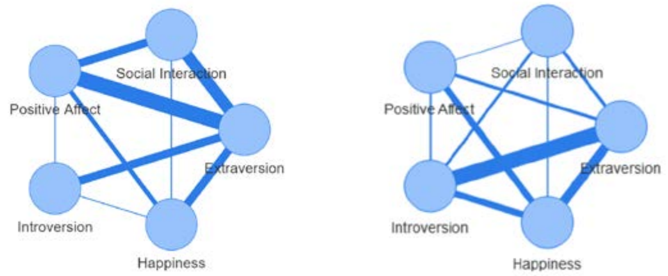

Figure 1. Visual representation of concept relations in the initial text (left) and the discussion page (right). Thicker lines between nodes represent more frequent occurrence.

In the first experiment, a pseudo-collaborative writing task was designed in which learners were instructed to improve an initial text by adding new perspectives and arguments from its accompanying discussion forum, while varying the presence or absence of network visualizations of relevant concepts in the two text environments. Two networks visualizations, which represent the co-occurrence of topic-relevant concepts in the same sentence in an initial text and the corresponding discussion forum (see Figure 1), were employed in a 2x2 design. It is assumed that concepts that occur in a sentence are semantically related (Bullinaria & Levy, 2007); thus, co-occurrence networks represent the conceptual structures of the two written environments. Previous research has shown that medium incongruity between initial information and the social environment can lead to integration of new knowledge in writing tasks (e.g., Moskaliuk, Kimmerle, & Cress, 2009). Thus, the text and the discussion board were constructed so that certain concept relations were relatively more represented in one environment, resulting in different conceptual structures. The task of the participants was to "add novel fact-based arguments from the discussion page into the article that [they] believe should be included in [an] initial text," a 500-word text entitled "Personality Traits and Happiness," to achieve the goal of "giving readers an overview of the relationship between personality traits and happiness". The discussion page was composed of 17 threaded conversations: 5 threads contained new information on the concept relations that were well-represented (i.e., occur frequently) in the text (e.g., extraversion-happiness), while 5 others threads contained new evidence supporting concept relations that were underrepresented in the text (i.e., occurred less frequently, such as introversion-happiness). The 7 remaining threads contained non-content relevant information.

Given that receiving two visualizations would enable comparison of the conceptual structures of the two text environments, participants supported by both visualizations were hypothesized to (a) view more threads on underrepresented concept pairs (number of discussion thread clicks); (b) mark these threads as helpful for achieving the task's goals (topic selection); and (c) write about those concept relations (keyword co-occurrence in the edited text), leading to (d) superior contribution quality in terms of form (e.g., word count, fact-based vs. opinion-based contributions, adequate rephrasing vs. copy-pasting) and content (e.g., integrating novel fact-based arguments) and higher subjective ratings on the usefulness of the visualizations.

Results

A total of 145 university students participated. A negative binomial regression analysis revealed that participants who were not supported by the initial text graph viewed 1.93 times more content-irrelevant threads ($B = .66$; $SE = .32$; 95%-CI [1.03;3.66]; $p = .04$). Those who received initial text graph support gave higher ratings on the usefulness of the visualization in determining the prominence of concept pairs in the text and discussion page ($F(2,141) = 7.43, p = .007$, partial eta=0.05).

However, no other significant main or interaction effects were found on views on content-relevant discussion topics, topic selection, keyword co-occurrence, or contribution quality. This suggests that visualizing the conceptual structure of the initial text was helpful in guiding learners to ignore irrelevant information from the written discourse, but this did not result in more integration of new knowledge. A follow-up study will collect qualitative (e.g., questionnaires) and quantitative data (e.g., log files) in order to determine how the visualizations were cognitively processed.

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Promoting Productive Failure in Collaborative Design Contexts: A Collaborative Failure-Management Learning Model

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Abstract: The ultimate goal of this research is to develop a model to guide the design of activities to facilitate children's learning from productive failure. In my dissertation, I focus on understanding how groups make sense of failure in collaborative design activities and how to break down these sense-making processes in order to facilitate the design of tools to help mitigate problems and enhance collective learning.

Background of the project

Productive failure has been explored extensively in business fields, but more work needs to be done to translate the findings for educational purposes. In business research, the productive failure learning model mostly focuses on failure competence. Scholars suggest that, organizations should avoid large failure by encouraging small productive failure (Cannon & Edmondson, 2005; Sitkin, 1992). Compared to large failure which can be emotionally devastating and costly, small productive failure can help detect errors that would prevent the escalation of the failure in the future (Cannon & Edmondson, 2005). To promote productive failure, scholars propose that business organizations should focus on developing a supportive culture that encourages people to take risk and learn from failure (Cannon & Edmondson, 2005). Productive failure research in education approaches the process of failure from a pedagogical perspective. Scholars in education conceptualize productive failure as creating a problem space for learners to gain valuable experience and opportunities for sense-making that help students construct deeper understanding of domain knowledge and problem-solving processes (Kapur, 2008). Even if students will feel frustrated because of the challenges, they will be more likely to recognize gaps in knowledge, increase information retention, and the likelihood of information retrieval, while reducing the "illusion of success" (Bjork, 1994). However, relatively speaking, educational research has conducted few failure management studies with children. What studies there are tend to focus on individual failure and individual learning outcomes, but in design contexts, where collaboration is the key to innovative problem solving, we need to understand failure management at the level of the group. Competence models that look at productive failure systematically, such as those used in business, have yet to be translated for educational purposes: to guide educators to facilitate children's learning at the level of the group. Therefore, there is (1) a need to understand how to adapt failure management competence model for educational purposes, (2) understand how groups manage failure as part of collaborative design processes, and (3) how to design activities to facilitate children's failure management in this type of context.

Methodology

For my dissertation, I piloted human-centered design curriculum with children ages 8-12 to identify existing strengths and weaknesses they experience during design thinking. I use Design Based Research (DBR) method proposed by Collins, Joseph and Bielaczyc's (2004), to evaluate and revise the curriculum and tools developed to support students' collective thinking processes. The findings from this round of iteration will be used to have in-depth understanding of the phenomenon and will also be used to inform the design in next iteration.

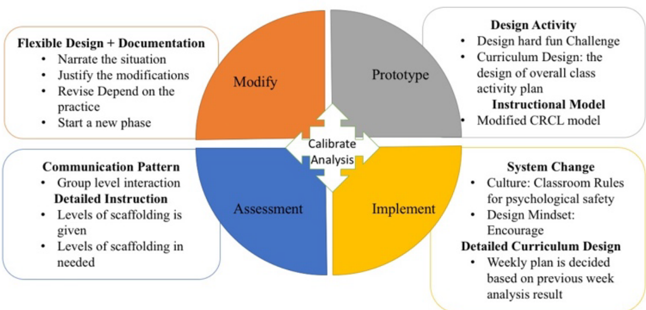

Figure 1. Four-phase design experiment model.

Data collection and data analysis

The data is collected in an elementary afterschool club in Central Pennsylvania. In this research, we recruit 16 fourth to sixth grade students. In total, we have 5 females and 11 males. Based on their grade, previous club experience, gender, and social emotional needs, we assign them into four groups. In this study, I collect six types of data – design document, video recording, audio recording, group and individual artifact, field notes, and design documents, but the major data source comes from video and audio recording.

Given the large amount of data, I will use techniques proposed by Jordan and Henderson (1995) to strategically filter the data. First, I will create content logs for all groups across 15 weeks' lesson. Then, I will select episodes that have rich discourse around productive failure and transcribe those episodes. Once they are transcribed, I will analyze collaborative failure management from a dual process – failure management process and collaborative sense making. I will use this information to revise the competence model proposed by Cannon and Edmondson (2005) to translate it for educational purposes to support group learning processes – reappraise, identify, analyze, and conduct design experiment. From this competence model, the group should first reappraise failure to recognize the learning opportunity small failure brings. For successful identification, the system should support groups to visualize failure and the group should actively seek feedback. Then, the group will initiate deep analysis to learn from the failure through inquiry. As the highest level of the competence, the group will be expected to conduct design experiments to test the solutions and optimize the design decision. This competence model is also helpful to identify children's potential progress they can make with the aid. To understand how group makes sense of failure, I will apply a collaborative discourse process coding rubric created by Borge and colleagues (2015). This rubric has two core competences – information synthesis and knowledge negation. The analysis of this process will give me insight on the level of complexity the discourse teams have around failure management.

Current status and challenges

I am currently in my data collection phrase. Besides that, I design weekly activities with my colleagues and negotiate lesson plans with an experienced facilitator. The major challenge I have right now is optimizing ways to help children crystalize their collective thinking processes so they are able to collectively reflect on and improve them. It is also challenging to integrate fun elements into reflection and engage them in productive failure sense making in an informal learning environment. Though scholars encourage reflection as effective pedagogy (Collins & Newman, 1988), it is challenging to engage them in deep thinking because children stop paying attention if the activity is not engaging. Finally, it is challenging to make failure explicit without making it too frustrating for students as they work on complex Human-Centered Design contexts. After preliminary analysis of the data, I find that children are good at rationalizing their designs, which make them unaware of failure. Thus providing feedback that points out failures is necessary, but how to do so in ways that promote deep thinking while managing negative emotions is very difficult.

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The Effect of Playing Portal 2 on Collaborative Problem Solving

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Abstract: The present project focuses on studying the impact of playing puzzle games on developing collaborative problem solving attitudes and skills in college students. Game mechanics present in the game Portal 2 will be identified and observed. The interaction among players will be coded and analyzed to recognize any impact game structures have on guiding the collaborative problem solving process among players.

Goals of the research

My dissertation proposal aims to answer the following research questions:

- How do games impact the development of 21st century collaborative problem solving attitudes and skills for college students when playing collaboratively the puzzle game Portal 2?
  - What types of interactions we observe between player-and-player, and player-and-game when playing co-op mode and single-player mode? How do these interactions evolve over time?
  - Which game elements are common between individual and co-op game modes and how do they impact collaborative problem solving?

Collaborative problem solving (CPS) is a valuable skill in the complex information age we live in, where working with others on solving problems is a daily practice for many (Griffin et al., 2011). Despite the importance of such skill, it is not the object of instruction in formal school settings. This is a missed opportunity and one that might be addressed by games and game play. Research has shown that learning occurs in games regardless of whether they were designed for that purpose or not (Gee 2003; Squire 2011; Barab et al., 2011).

By studying the designed interactions occurring in games we can derive some insightful implications on how successful computer supported collaborative learning (CSCL) gaming environments can be designed and how to leverage digital games in formal and informal learning environments.

Research background

Defining games

McGonigal (2011) has defined games as “A voluntary attempt to overcome unnecessary obstacles.” According to her, games share four defining traits: a goal, rules, feedback system, and voluntary participation. Schell (2014) identified four basic elements that form a game: Mechanics, story, technology and aesthetics. This proposal focuses on the mechanics and story elements. Mechanics are the procedures and rules of the game. They describe the goal of the game, how players can or cannot try to achieve the goal, and what happens when they try. In other words, mechanics describe the components of the game at the level of data presentation and algorithm (Hunicke et al., 2004). Story is the sequence of events that unfolds in the game.

Portal 2

Portal 2 is a popular first-person puzzle video game developed and published by Valve Corporation. This game can be played in two modes: Single player and Co-op. Players take a role of Chell in the game and explore and interact with the environment. *Portal 2* uses different game mechanics. The goal of *Portal 2* is to get to an exit door by using a series of tools. The primary game mechanic is the portal gun, which can create two portals allowing players to move through space. *Portal 2* uses the story element to motivate players, provide contexts and give hints to players on how to proceed. This research aim to analyze the story and different mechanics used in *Portal 2* using Schell’s classification, with the purpose of identifying the structures that might have an impact on collaborative problem solving.

Collaborative problem solving

Different studies have showed positive impact of playing games on collaboration and problem solving. Using a quasi-experimental design, Sanchez & Olivares (2011) found that the 8th grade students in the team that played mobile serious games developed problem solving and collaborative skills, achieved higher perception of their own collaborative skills and higher scores in plan execution of the problem-solving cycle when compared to those who had traditional classes. Inpken et al. (1995) compared solitary, parallel and collaborative game play.

In parallel game play, players played next to each other, while in collaborative game play they shared a computer. They found that collaborative game play led to significantly higher scores on motivation and learning outcomes.

My dissertation research will use the 21st Century Skills framework proposed by PISA (2015) to measure collaborative problem solving skills. According to PISA, collaborative problem solving competency is the capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills and efforts to reach that solution (PISA 2015). PISA identifies three core competencies for CPS:

1. Establishing and maintaining shared understanding;
2. Taking appropriate action to solve the problem;
3. Establishing and maintaining team organization.

Methods

I will use Schell's classification of game elements to identify the game structures to be observed during game play. PISA framework will be modified to fit describing collaborative problem solving in game environments. College Students will be assigned randomly to two groups. One group will play the game in solo mode where the player "collaborates" with the agent in the game, while participants in the other group will play in pairs the co-op mode of the game. This research will compare these two groups playing similarly difficult levels of the game. Pre-Post tests (Shute et al., 2013) will be used to measure attitudes towards and competency in collaborative problem solving skills before and after game play. The modified PISA framework will be used to code the collaborative problem solving skills observed during game play.

Issues to explore with the CSCL doctoral consortium

1. Are the methods selected for this study appropriate? What recommendations do the community have to improve the robustness of this research proposal?
2. What suggestions do the community has in terms of collecting data and finding participants for this research?

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The Role of Context in Virtual Environments: Investigating Student Reasoning With Online Places

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Abstract: Proponents of place-based learning argue that situating learning in students' own local place increases engagement, interest, and science learning. In CSCL, we often design virtual learning environments, which can facilitate experiencing distant places using high-quality immersive, authentic curricula. However, research may need to consider the conditions under which local place matters in relationship to virtual environments. Using a place-based simulation, our preliminary work found that students showed different changes in outcomes based on their physical location of play. My dissertation will investigate why a local context may increase outcomes and how simulated contexts may affect students' reasoning skills.

Project background

Gruenewald (2003) claims that place-based learning is the most effective form of environmental education, which emphasizes a close connection between where students live and what students learn (Smith & Sobel, 2010). Such curricula share three key characteristics: (1) students engage in problem-based activities; (2) these problems contain authentic issues tied to a particular place; and (3) these problems are based the *students' own local place* – that is, the place where students live (Gruenewald, 2003). Proponents of place-based learning argue that situating learning in students' own local place increases civic and community engagement, interest in environmental issues, and science learning (Ardoin, 2006; Powers, 2004). However, place-based curricula are centered not only on students' own local place, but are authentic, problem-based learning experiences, which Smith and Sobel (2010) argue is a key benefit to this pedagogy. Similarly, research in CSCL has shown authentic experiences (Brown, Collins, & Duguid, 1989; Järvelä, Häkkinen, Arvaja, & Leinonen, 2004) and problem-based activities are beneficial for learning (Hmelo-Silver, 2004). Thus, it is not clear whether place, and specifically students' own local place, improves student outcomes or whether the results are confounded with the effects of authenticity and problem-based learning.

One way to test this differentiation is to simulate experience, and Shaffer et al (2005) argue that simulations can reproduce rich, social contexts, in which students can assume the roles of professionals and solve a wide-range of problems. For my preliminary study, we focused on simulations that engage students with authentic activities and problem-based learning about a specific virtual location, which we define as *place-based simulations*. One example of a place-based simulation is the virtual internship, *LandScience*, where teams of students develop and justify land-use plans that meet the needs of competing stakeholders. In this CSCL environment, students work individually and in teams to develop a rezoning plan using a geographic information system (GIS) model for Lowell, Massachusetts. Through participation in *LandScience,* students learn about complex eco-social systems and learn to think like urban planners in the context of a real city (Bagley & Shaffer, 2011). Place-based simulations, like *LandScience*, have the potential to test the effect of place by having students in multiple locations engage in the same authentic learning experience about a specific place, which may be local to some students and non-local to other students.

Proposed research

While the connection between local place and place-based education is implicit in research about learning, my preliminary study outlined below is the first work we are aware of that provides empirical evidence to support this connection. Previous studies and definitions of place-based education have assumed a local context, but this may be due to the physical constraints of what places can be experienced in an engaging and immersive way. Thus, understanding the underlying reasons why a local context may increase engagement, motivation, and other outcomes represents a key challenge in the development and assessment of virtual environments.

Preliminary study

We collected survey responses from 94 high-school students who engaged in 10 implementations of *LandScience.* Since *LandScience* is set in Lowell, MA, we considered that students within Massachusetts experienced a *local place-based simulation* (*n* =68) while students in other states experienced the internship as a *non-local place-based simulation* (*n*=26). The survey asked students about their knowledge and ability to engage in civic activities, interest in cities and the environment, and ability to describe and provide examples of scientific models.

We conducted a series of nested multiple regression analyses to predict the change in outcome for civic engagement and interest in cities and the environment. Because the ability to provide an example of a scientific model is a dichotomous variable we performed a series of nested logistic regressions to predict this outcome. In each analysis, we tested the following predictors: location, civic engagement pretest score, interest pretest score, and science model example pretest score. Even though all students engaged in the same authentic activities and problem-based learning about a specific place, we found that students showed different changes in outcomes based on their location of play. When controlling for the relevant pretest we found that students who engaged in place-based simulations about their state had higher changes in civic engagement and interest. Students in engaging in a local place-based simulation also were more likely to be able to identify a science model example after the intervention.

Research questions and methods

Using place-based simulations, our results suggest that even when students experience authentic activities and problem-based learning about a specific place there is an interaction between local place and online place. Therefore, the overarching goal of my dissertation research will be to investigate why local contexts may support greater outcome changes. How might students feel more ownership of the simulation when the context is local? How might working with a model-based simulation be more concrete or abstract depending on your location? What is the underlying mechanism that makes local context meaningful and productive?

To address these questions, I will collect data from students who engaged in *LandScience* in four forms (1) team chat logs, (2) individual student notebook entries and final proposal, (3) each team's final map choices, and (4) student pre amd post survey responses. To begin my analysis, I will use data from 63 past implementations of Land Science. I will use the existing chat logs and notebooks to develop and validate a coding scheme to understand the role of virtual experience in collaboration and decision-making processes. I will investigate the quality of students' land-use proposals by measuring how many stakeholder thresholds were met by a team's final map. I will analyze student pre- and posttest responses to open-ended and Likert-scale questions about civic engagement, interest, science modeling, game immersion, model-based reasoning, and connections to place.

Issues for workshop

This workshop will give me an opportunity to discuss the role of context in virtual environments. Our preliminary findings show that local context may influence how students perceive and experience an online curriculum. While simulations can facilitate experiencing distant places using high-quality immersive, authentic curriculum, further research should consider the conditions under which local place matters in relationship to virtual environments. By considering the underlying mechanism and advantages of local contexts, we can learn more about creating meaningful adaptations for new user groups. Further discussion of these issues will benefit the CSCL and Learning Sciences community to understand the role of context within virtual environments and model-based reasoning.

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Conceptualizing Scaffolding for Science Learning in Classrooms and Museums Using Mixed-Methods Approaches

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Abstract: Scaffolding may support learners working with complex problems, but how to best integrate distributed scaffolds in formal and informal contexts is not well understood. In response, I will integrate distributed scaffolds (e.g., prompts, an e-textbook) in a science curriculum and a museum exhibit. Using a mixed-methods approach, I will analyze how particular patterns of distributed scaffolds support learners in classrooms and museums. These findings may impact how we conceptualize scaffolding and design learning environments.

Introduction

Learners working with complex problems in inquiry-based learning need support from multiple sources, such as experts, tools, and technology. Providing multiple sources of support distributes entry points for learning that accommodate different needs (Tabak, 2004). However, we have yet to understand how to best integrate these sources, or *distributed scaffolds*, into learning environments (Puntambekar & Kolodner, 2005). In response, I will integrate scaffolds in two environments, classrooms and museums, to understand how differences in learning contexts mediate learners' interactions with scaffolds. Scaffolds may include educators, peers, an e-textbook, physical and virtual experiments, and informal assessments. Technology may play an interesting role depending on how many learners it can support simultaneously. Studying the interplay between these scaffolds, especially in patterns and sequencing, is critical to understanding best practices for implementing scaffolds in classrooms and museums.

The objectives of this work are to understand the interplay between distributed scaffolds and effective combinations of scaffolds in each context. Another goal is to identify characteristics of each context that may be leveraged to support inquiry in curricula and exhibits. By studying the integration of distributed scaffolds in two contexts, we can better conceptualize context-mediated characteristics and synergistic design of scaffolds.

Theoretical grounding

Sociocultural theorists posit that learning is mediated through interactions with others (Vygotsky, 1978). A cornerstone of sociocultural theory, the *zone of proximal development* (ZPD), refers to what can be accomplished independently and with assistance (Vygotsky, 1978). One way to support learning in the ZPD is through *scaffolding*. Scaffolding is conceptualized as a dialogue in which an expert establishes common goals with a learner, monitors understanding, provides titrated support, and gradually reduces support (Puntambekar & Kolodner, 2005). Scaffolding may also apply to contexts with multiple learners (e.g., Smit et al., 2012). To simultaneously support multiple ZPDs, we may integrate *distributed scaffolds* that provide targeted assistance across multiple sources (Tabak, 2004). Distributed scaffolds may include social groups, educators, objects, tools, activities, and technology (Ash, 2004; Griffin, 2012; Yoon et al., 2013). Integrating distributed scaffolds may support diverse learners' ZPDs (Ash, 2004) and encourage deeper inquiry (Yoon et al., 2013).

Methods

To study distributed scaffolds, I will use a multi-layered approach that targets each source of support to understand its role. Here, I describe the study design and planned data procedures for the distributed scaffolds.

This work uses activities from *Growing Healthy Plants* (GHP), an eight-week science curriculum for middle-school students centered around a design challenge that drives inquiry about plants' roles in ecosystems. For my dissertation, I will focus on activities about genetics that include scaffolds such as prompts, simulations, e-textbook explorations, and hands-on activities. These activities are being implemented in two contexts: a semi-rural middle school (as part of the curriculum) and a medium-sized science museum (as a pop-up exhibit).

In each context, I will analyze how learners' interactions with distributed scaffolds support their inquiry and how context mediates support. To do this, I will collect (i) video and audio data of participation and (ii) log data from e-textbook explorations. In classrooms, I will collect (iii) written products and (iv) content test scores. In museums, I will collect (v) visitors' feedback about conceptual relationships on a "feedback board."

For video and audio data, I will use discourse analysis (Ash, 2004; Puntambekar, 2013) to analyze how learners engage with distributed scaffolds. I will compare proportions of coded discourse using z-score tests of homogeneity to identify significant patterns. Coded discourse will also serve as input for graphical Markov models that describe probabilistic sequences in discourse. For the e-textbook log data, I will use Markov models and sequential pattern mining to identify navigation patterns (Witten et al., 2011) and paths of inquiry (e.g., Dornfeld et al., 2017) while using theory to differentiate "noisy" and meaningful patterns. I will use natural language processing (e.g., Sherin, 2012) to analyze students' written products and statistical tests to analyze content test scores, moving toward triangulating students' conceptual outcomes. Similarly, grounded coding of the "feedback board" may reveal salient themes for visitors.

Progress and issues

This dissertation is based on pilot studies of scaffolding strategies (Dornfeld, 2016), collaborative learning (Dornfeld & Puntambekar, 2016), and mixed-methods approaches (Dornfeld et al., 2017). For the workshop, I would benefit from discussing how to model mixed-methods approaches and reconcile findings from multiple data sources (e.g., Suthers & Medina, 2011). Identifying assumptions about scaffolding and analytical approaches is also critical for the success of this work.

Conclusion

Learners engaged in complex problem-solving benefit from distributed scaffolds, but how to best integrate distributed scaffolds is not well understood. In this dissertation, I will implement distributed scaffolds in classrooms and museums to investigate (i) the interplay between distributed scaffolds; ii) effective combinations of scaffolds; and (iii) characteristics of each context that impact scaffolding. Findings may impact how we conceptualize scaffolding across contexts, design learning environments, and combine analytical approaches for diverse data.

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Evolution of Knowledge Building Teacher Professional Development Communities

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Goals of the research

The purpose of my thesis research is to explore the diffusion of Knowledge Building as an innovative pedagogy within and across schools and school boards in a supportive culture for transforming educational practice. I aim to develop an understanding of the adoption process that is affected by factors at multiple levels of school system influencing adoption decisions and buy-in by teachers, administrators, students, and policy makers. I take advantage of initiatives spearheaded by the Ontario Ministry of Education and three principals' councils to explore the potential of Knowledge Building in Ontario schools. Through their Leading Student Achievement: Networks for Learning (LSA) initiative they place leadership capacity of principals and vice-principals at the center of their work, assuming principals' leadership can affect student success through enabling teachers to incorporate increasingly effective teaching and learning approaches (Leithwood & Miller, 2012). LSA has been active since 2005. In the 2013-2014 school year, Knowledge Building, set forth as one of five foundational models in the Handbook of the Learning Sciences (Sawyer, 2006), was adopted by the LSA project. Ontario's uptake of Knowledge Building provides a particularly rich context for studying Knowledge Building professional development.

Background

If education is to meet needs for a knowledge society, dramatic shifts in national reform agendas, teacher education, and mindsets of administrators and teachers are required to improve professional development and student outcomes (Darling-Hammond & McLaughlin, 1995; Fullan, 2007). Knowledge Building --the production and continual improvement of ideas of value to a community (Scardamalia & Bereiter, 2003) --represents a particularly demanding model and pedagogy for professional development and new forms of teacher-student engagement, as it adds the need to acculturate students into knowledge creating cultures in which teachers and students alike embrace complexity of real-world problem solving and take collective responsibility for knowledge advancement. Knowledge Building engages participants in technology-mediated work to sustain community interactions and formation of collaborative networks—a community of communities committed to sustained idea improvement. Overall, Knowledge Building requires a shift from traditional schooling to schools as knowledge creating organizations using modern technology that supports sustained creative work with ideas.

The diffusion of innovation research (Rogers, 2003) provides background for my thesis study. According to Rogers, the innovation-decision process as "an information-seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation" (p. 172).

Innovation-decision process involves five stages: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. Rogers (2003) defines variables that determine the rate of adoption of innovation in five categories: (1) Perceived attributes of innovation (e.g. relative advantages, compatibility, complexity etc.), (2) Type of innovation decision (optional, collective, and authority), (3) Communication channels (e.g. mass media or personal networks) (4) nature of the social system, and (5) extent of change agents' promotion efforts. In addition, prior conditions such as previous experiences, feel of need and/or problem, and innovativeness as a personal characteristic have a profound effect on the innovation-decision. At the end of the innovation-decision process, people either adopt or reject the innovation. Indeed, it is not the end of the process; there might be exchange between adoption and rejection behaviour. Someone who adopts an innovation either continues on her/his decision or it results with discontinuance. Similarly, a rejection might continue or the decision might change and the person might choose to be later adopter.

I explore diffusion of Knowledge Building as an educational innovation through its four key components: innovation, communication channels, time, and social system. Within this framework, I explore the factors that affect the innovation-decisions of teachers and principals' and the contribution of the LSA project to dissemination.

Methodology

This research starts with a "big picture" account of diffusion of Knowledge Building in Ontario using document analysis, accompanied by a case study of work within and across schools within one school board
Data are analyzed to address three research questions.

1. What is the evidence of diffusion of Knowledge Building among teachers within and across the schools?
2. What evidence exists that teachers, administrators, or students implement effective practice grounded in Knowledge Building principles?
3. What evidence is there that teachers and students are engaged in Knowledge Building Communities?

Settings, participants, and data collection
My research proceeds in two phases. The first is a big-picture analysis of the LSA effort to seed Knowledge Building in public schools across Ontario. I provide an account of public meetings, webinars, and activities to engage administrators and teachers, including number and type of events and markers of principal and teacher engagement (e.g., questions, comments, presentations, stories) and content analysis of video records on the Ministry's Learning Exchange website. The second is case-study analysis, starting with one teacher in one school spreading to other schools in Upper Grand School District Board (UGDSB). I analyze the spread in three schools. The participant group of the case study consists of 11 teachers and 4 administrators from 3 different schools in the UGDSB. For analysis purposes I use records and transcripts of resources and events, research reports, transcripts of video and audio recordings and/or online discourse, and interview data where available. I use semi-structured interviews conducted with principals and teachers from four schools at UGDSB. The participant teachers will also provide the materials used in Knowledge Building classrooms.

Current status
The first phase of data collection is complete. For the second phase interviews with 11 teachers and 4 principals are complete. Next steps require analyzing data from both phases and merging qualitative, social, and semantic analyses across both phases, developing indicators of spread within and across schools, and developing recommendations for further strengthening of professional development and curriculum design.

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Teacher Leadership in Information and Communications Technology (ICT) Reform

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Abstract: Teacher leadership is vital in sustaining school reform and supporting educational improvement for students. Recent research on ICT reforms for educational improvement in schools suggests that leadership required for successful implementations is one which is beyond the sole leadership from the principal. For successful implementations of ICT reforms, there exists a need for teacher leaders leading from the middle and from within, who act as the social glue that holds it all together. This study will adopt a naturalistic inquiry approach, using case study of a Future School in Singapore to generate an in depth understanding of how teacher leadership is practiced, develops and its impact and influence in ICT reform.

Background and goals of research

The teaching profession in many parts of the world is either in the midst or on the verge of great transformation (Hargreaves, 2000). The last decade has seen a new era of teacher professionalization and heightened awareness of teacher professionalism through the emergence of and greater recognition of teacher leadership in various countries. Some examples include: UK's "Teacher-led School Improvement" (Frost et al., 2000), Australia's "Developing Teacher Leaders" (Crowther et al., 2009), Italy's development of "funzione obiettivo" towards teacher leadership (Brotto, 2003) and US's "Teach to Lead Initiative" (U.S. Department of Education, 2014). In Singapore, a similar emphasis is observed with the renewed call for teacher-led professionalism by the Ministry of Education (MOE), teachers are called to "lead, care and inspire", through exercising teacher leadership and ownership in a teacher-led culture of professional excellence (AST, 2012).

In the study of educational leadership, the focus has always been on school leadership exercised by the school principals (York-Barr & Duke, 2004). Though school principal's leadership has an effect on teachers' behaviours and attitudes, it is becoming more evident that teacher leadership and ownership is important for educational change to happen, teachers need to own and lead their curriculum changes (Price, 2011; Wahlstrom & Louis, 2008). As stated by Hargreaves and Fullan (2012, p.45), "sustainable improvement can never be done to or even for teachers. It can only ever be achieved by and with them." Teacher leadership is vital in sustaining school reform and supporting educational improvement for students. Teacher leadership and ownership is seen to be even more important in ICT reforms for educational improvement since ICT is not a core subject or teaching subject in Singapore. Teachers' buy in and ownership is essential before they would support the ICT reforms brought about by the Ministry of Education's (MOE) ICT Masterplans. Although research indicates that leadership is critical in the ICT reform implementation and diffusion (Busher & Harris, 1999; Sammons, Hillman, & Mortimore, 1995), it does not detail the actual leadership practices apart from perceptions of leadership based on surveys and interviews (Flanagan & Jacobsen, 2003; Martinez, 2002). Furthermore, recent research on ICT reforms for educational improvement in schools suggests that the leadership required for successful implementations is one which is beyond the sole leadership from the school principal (Anderson & Dexter, 2005; Ho, 2009). This suggests that teacher leaders and teacher leadership is becoming recognized as an important leadership source for sustained ICT reforms. In addition, school principals are posted from school to school on a regular basis (usually after six years), for ICT reforms to continue, there lies a need for a stable source of leadership from within the school; teacher leadership from among the ranks who know and build upon the school culture to create conditions favourable for ICT reforms.

Given the complexity involved in ICT implementations and reforms, which involved an understanding of subject area, pedagogical knowledge and ICT affordances (Franklin, 2005; Mumtaz, 2000; Pierson, 2001); schools today are too complex for school principals to lead alone and teacher leaders are necessary to complement or step into some of the responsibilities of school leaders (Kennedy, 2005; Lieberman, 1996). For successful implementations of ICT reforms, there exists a need for teacher leaders leading from the middle and from within, who act as the social glue that holds it all together. It is now close to two decades since the launch of the first ICT Masterplan in 1997, and the second ICT Masterplan in 2002. Singapore is now in its fourth ICT Masterplan (2015 – 2020). Tremendous amount of resources (i.e. financial, manpower, time, etc.) have been invested in the implementations of the ICT Masterplans in schools across the nation. It is timely for a study to investigate into how the emergent teacher leadership develops and its effects on ICT reforms for educational improvement in the Singapore context.

Research questions

RQ1: How does teacher leadership develop for ICT reform?

- Who are the teacher leaders for ICT reform?
- How do they show leadership?

RQ2: How do teacher leaders perceive themselves and others as they work in their teacher leadership roles?

RQ3: What factors enable or constrain teacher leadership?

RQ4: What impact do teacher leaders have on ICT reform for educational improvement?

Research methodology

This study will adopt a naturalistic inquiry approach. A case study will be conducted on the phenomenon in question in a Future School deeply engaged in sustainable ICT reforms and implementation. Schools awarded the Future School status could tap into a pool of $80million for their ICT reforms (MOE, 2008). With greater access to resources for ICT reforms and a mandate to transform learning, a Future School will be a suitable site for a case study as there will be more opportunities for the investigation of how teacher leadership develops and its effects on ICT reforms for educational improvement. The case study methodology will allow the researcher to study the phenomenon "in depth within its real-life context" (Yin, 2009, p.18). As such, it allows the researcher to gain particular insight and understanding of the complex phenomenon in its specific context (Stake, 1995, Yin, 2009). The case study approach will be adopted to explore the complexities of how teacher leadership develops and its effects on ICT reform.

Data to examine the context will be drawn from observation field notes from the teacher meetings, curriculum plans, as well as interviews with key persons involved in the ICT reform. Observations of teacher leadership during meetings and in school events relating to the ICT reform, as well as discussions with persons involved in the ICT reform will enable the "interplay between what is said is done and what is experienced as being done" (Gunter, 2001, p. 59) for data triangulation. Semi-structured interviews will be conducted with each of the key persons. The interviews will be transcribed verbatim and returned to the participants for member-checking. The qualitative research data will be analyzed using the general inductive approach (Thomas, 2006). Specific domains and topics to be investigated will be identified after data collection. A series of repeated readings and interpretations will be made of the data by the researcher. General categories will be "derived from multiple readings of the raw data" (p.241). Overlapping codes and similar categories will be merged to formulate key themes.

The intent is to provide a rich descriptive account of the sustained implementation of ICT reform in a selected school, so as to surface details of how teacher leadership is practiced, develops and its effects on ICT reforms for educational improvement. In so doing, to contribute knowledge in current literature.

Current status and issues to explore

For the implementation of ICT reforms through the ICT Masterplans in Singapore, there exist a wide range of teacher leaders providing teacher leadership from different levels, leading through formal and informal leadership positions such as formally appointed positional roles like Head of Department for ICT and non-positional roles like ICT mentors. Different role types afforded different leverages for teacher leadership. Furthermore, with the ICT Masterplan in its 4th iteration, it is timely to examine how teacher leadership develops in ICT reforms for educational improvements as much resource have been invested through the various ICT Masterplans in schools. To the best of the researcher's knowledge, the study of teacher leadership is in its nascent stages in Singapore context with the recent emphasis on teacher-led culture of professional excellence. As there is little research on how teacher leadership develops and its effects on ICT reforms in the Singapore context, it is an uncharted territory. Findings from this research seeks to contribute to knowledge and provide some insights into sustaining ICT reforms in schools as evaluated against the ICT masterplan's four approaches and requirements on schools: (a) deep ICT integration, (b) sustained professional learning, (c) translational research, (d) connected ICT learning ecosystem.

Preliminary work has been done in non ICT or CSCL environments to explore how teacher leadership develops in Singapore schools. Initial analysis shows that two factors stand out in the unique characteristics of the Singapore education system, namely respect for (a) seniority through the recognition of experience and (b) hierarchy (power distance) through the well-established career tracks for education officers. I seek to further explore these two factors (a) seniority and (b) hierarchy in the context of ICT reform in this study and further understanding through discussion with peers and faculty at the Doctoral Consortium workshop.

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