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KBSI2018 PROCEEDINGS

2018 Knowledge Building Summer Institute
Toronto, Ontario, Canada
August 14-17, 2018

Knowlege Building International

22nd Annual Knowledge Building Summer Institute
Knowledge Building: A Place for Everyone in a Knowledge Society
August 14-17, 2018
Toronto, Ontario, Canada

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The students from San Francisco Javier School, San Luis de Potosí, Mexico; St. Michel, Quebec, Canada; Lok Sin Tong Wong Chung Ming Secondary School, Hong Kong; St. Anne's Elementary School & Dundas Valley Secondary School, Ontario, Canada.
Thanks to Ann Russell and her team for welcoming the Design Experiment group to The Michener Institute of Education at UHN.

A special thanks to our colleagues, who assisted us with the review process:
Alisa Acosta, Kate Bielaczyc, Maria Bogouslavsky, Renato Carvalho, Donatella Cesareni, Bodong Chen, Stacy Costa, Frank de Jong, Joseph Gallifa, Huang-Yao Hong, Robert Huang, Ahmad Khanlari, Derya Kici, Pei-Yi Lin, Francesc Martinez, Yoshiaki Matsuzawa, Sandy McAuley, Cesar Nunes, Jun Oshima, Ritsuko Oshima, Hyejin Park, Don Philip, Joanna Qi, Monica Resendes, Giuseppe Ritella, Hai-Peng Wan, Li-Jen Wang, Joel Wiebe, Guangji Yuan, Anna Zhou, Gaoxia Zhu

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Scripted Idea Improvement in a Learning Community Curriculum for Grade 12 Biology

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Abstract: This paper describes a learning community curriculum and corresponding technology environment called *CKBiology*, which was informed by a pedagogical model called *Knowledge Community and Inquiry (KCI)*. Like Knowledge Building (KB), KCI prioritizes epistemic agency, collective cognitive responsibility, and idea improvement. However, in a departure from KB, an important aspect of KCI is the design of curricular *scripts*, which serve to guide the activities of the community towards particular learning goals. In this paper, we present the design of a CKBiology script that includes explicit activities directed at idea-improvement. We then perform an analysis of one CKBiology knowledge base in order to identify the nature of the idea-improvements therein. Our results showed that build-ons tended to be applied to notes containing fewer words and no supporting images. Our results also revealed a substantial proportion of students who "satisficed" their idea improvement activities, highlighting a tension between the values of the learning community (e.g. collective cognitive responsibility) and the merit-based aspects of schooling.

Introduction

What it takes to become a well-informed, virtuous citizen has changed dramatically over the past few decades. Preparing students to become effective citizens means that they should have the knowledge and skills needed to live in a complex and diverse global society, to participate in constructive deliberation, to collaborate with other groups, and to take action to create a more just and compassionate world. These values, along with the affordances of networked technologies, have led to the development of various "learning community" approaches to education (Bielaczyc & Collins, 1999; Brown, 1997; Peters & Slotta, 2010). Learning communities are characterized by "a culture of learning in which all participants are involved in a collective effort of understanding" (Bielaczyc & Collins, 1999, p. 2). Learning communities prioritize students' diverse identities, ideas, perspectives, and experiences, positioning these at the forefront of classroom activities. Students work within different "social planes" (Dillenbourg, 2015) in the pursuit of shared learning goals—contributing ideas as individuals, negotiating and improving upon these ideas in small groups, and expanding these ideas as a whole class. In so doing, students foster a collective epistemology and are given a high degree of agency in regulating their activities.

This paper describes a learning community curriculum for Grade 12 Biology called *CKBiology*, which was grounded in a pedagogical model called *Knowledge Community and Inquiry* (KCI; Slotta & Peters, 2008). Similar to Knowledge Building (KB; Scardamalia & Bereiter, 2006, 2014), students in a KCI classroom work together as a community, contributing ideas to a shared knowledge base, building upon each other's knowledge and nurturing a collective epistemology. However in a departure from KB, an important aspect of KCI is the design of curricular *scripts* (Fischer, Slotta, et al., 2013) which specify the activity sequences, materials, student groupings, and technology elements that serve to guide the inquiry toward particular learning goals (Tissenbaum, Lui, & Slotta, 2012). In alignment with the KBSI theme of *Pervasive Knowledge Building: Multi-Level, Global, Inclusive*, this paper describes how a KCI script can be used to advance the KB principle of *improvable ideas*. Here, we respond to the following three research questions:

1. How can idea improvement be supported within a KCI script?
2. How do notes in the knowledge base vary with respect to the levels of idea improvement they receive?
3. How do students vary in their contributions towards improving other students' ideas?

Theoretical Background

To be successful, computer-supported collaborative learning (CSCL) depends on effective interactions among learners. However, merely assigning students a collaborative task and providing them with communication tools is not sufficient to ensure that their interactions will be productive (Weinberger, Kollar, Dimitriadis, Mäkitalo-Siegl, & Fischer, 2009). Research has shown that learners often struggle to collaborate effectively, to select appropriate strategies, to mutually regulate their behaviour, and to understand the goals or nature of their assigned tasks (Kobbe et al., 2007; Nikol Rummel & Spada, 2007; Weinberger, Stegmann, Fischer, & Mandl, 2007). As well, the more an activity diverges from 'traditional' classroom experiences, the more difficult it may be for students to engage in effective collaborations since they may have little or no experience with the requisite CSCL practices (Fischer, Kollar, Stegmann, & Wecker, 2013).

One approach to supporting collaborative learning is through the use of pedagogical *scripts*. Broadly, a script is "a device by which participants' actions are regulated towards some ideal" (Suthers, 2007 p. 176). A script is a formalism for capturing the pedagogical structure of a learning design (Tissenbaum & Slotta, 2012). It differs from a "lesson plan" in that a lesson plan is typically centered around *teaching* activities, whereas a script is centered around *learners and their interactions* (Dillenbourg, 2004). Furthermore, a script reflects an underlying theoretical model or hypothesis concerning the *mechanisms* by which learning occurs—i.e. how particular types of interactions are supposed to produce the desired learning effects (Dillenbourg, 2002). Similar to a theatrical script, a pedagogical script includes a set of instructions that specifies the pedagogical scenario (i.e. the "play"), the sequence and timing of activities (i.e. the "scenes"), the responsibilities of individuals (i.e. the "actors" and "roles"), and how and when to constrain particular interactions (i.e. the "scriptlets"; Fischer, Kollar, et al., 2013). A script can be considered a specific type of instructional *scaffold* (Quintana et al., 2004), in that it serves to break down a complex learning process into more cognitively manageable pieces and induce interactions that learners would not otherwise engage in without additional support (Tissenbaum & Slotta, 2015; Weinberger et al., 2009).

A major issue in scripting research is concerned with *the flexibility* and *degree of coercion* of a script. In their pioneering contribution to AI and cognitive science research, Schank and Abelson (1977) put forth a theory on scripting that was based on a computational model of *how people understand stories*. Their formulation of scripts was founded upon the assumption that the human mind worked like a computer program—accessing data structures and drawing long sequences of logical conclusions (Schank & Abelson, 1977; Stahl & Pfister, 2007). Attempts to extend Schank and Abelson's theory beyond its original domain of *understanding stories* (i.e. in an effort to explain other types of human behaviour) have shown to be problematic (Stahl & Pfister, 2007). For example, early educational applications of scripting tended to emphasize prescribed, recurrent, predictable, and fixed patterns of student behaviour, which put it at odds with constructivist approaches that prioritized student agency and creative work with ideas (Bereiter et al., 2017). These early educational scripts could be described as having a high *degree of coercion*, meaning that learners were given very little freedom to escape or deviate from the script (Dillenbourg, 2002). Related to *coercion* is the idea of *over-scripting*, which is when interactions are constrained to such a degree that the collaboration feels unnatural and sterile (Dillenbourg, 2002).

Unlike early approaches to educational scripting, more recent work in CSCL has supported the design of flexible scripts that serve as *situated resources* rather than as impenetrable plans for action (Dillenbourg & Jermann, 2007; Stahl & Pfister, 2007). Fischer and Vogel (in Bereiter et al., 2017) address the aspect of flexibility by distinguishing between scripts that are *adaptive* versus *adaptable*. An *adaptive* script is one in which the level of scaffolding is adjusted based on students' actions, such that an appropriate amount of support is provided when and where it is most needed (Diziol, Walker, Rummel, & Koedinger, 2010). On the other hand, an *adaptable* script is one that can be changed directly by those using it, allowing students to act in more self-regulated ways (Fischer & Vogel, in Bereiter et al., 2017). Both *adaptive* and *adaptable* scripts are controlled by real-time decisions that emerge as the script is being enacted.

Knowledge Community and Inquiry

Knowledge Community and Inquiry (KCI) is a learning community model developed in the mid-2000s by Jim Slotta at the University of Toronto (Slotta & Peters, 2008). Inspired by KB pedagogy, KCI and KB are theoretically compatible, however these perspectives are conceptually distinct—each differing with respect to the objectives of the community, the centrality of student-generated ideas, as well as the level of emphasis placed on prescribed learning goals and activity structures (i.e. scripts). KCI provides structural requirements and design principles that allow (1) an epistemological orientation to help students understand the nature of science and learning communities, (2) a knowledge base that is indexed to the targeted science domain, (3) an inquiry script that specifies collective, collaborative and individual activities in which students construct the knowledge base and then use it as a resource for subsequent inquiry, and (4) student outcomes that allow assessment of progress on targeted learning goals. The model guides the design of activity sequences including individual, group (e.g., jigsaw) and whole-class activities (e.g., brainstorm, resource collecting), ensuring that all students progress on the learning goals. These activity scripts are co-designed with the teacher, and are tailored to meet the unique needs of his/her context and students (Slotta & Najafi, 2012). During classroom enactment, the teacher is instrumental in orchestrating the activities and has a clearly-defined role within the script (Madeira, Fong, & Messina, 2012). Rather than merely serving as a "guide on the side," the teacher becomes a "mentor in the centre," participating in the KCI community as an expert collaborator and mentor. KCI curriculum designs are guided by four design principles, each accompanied by a set of epistemological commitments, pedagogical affordances, and technology elements (Slotta, 2014).

Methodology

This project employed a design-based research (DBR) methodology—an approach that has been widely used in the learning sciences to support the creation and development of innovative learning environments through parallel processes of design, evaluation, and theory-building (Brown, 1992; Collins, 1992; Edelson, 2002). In order to support a KCI approach throughout this course, we developed a custom technology environment called *CKBiology*. CKBiology was designed in close collaboration with our co-design teacher and reflects the unique design constraints of her course structure, her students, and her school context. Accordingly, CKBiology is a bespoke technology that was custom tailored to support our KCI script. CKBiology was designed and developed over the course of five design cycles during the 2016-2017 academic year.

In the first part of our analysis, we report on the design narrative from the fourth design cycle—the most comprehensive implementation of CKBiology. In the second part of our analysis, we use a case-study approach to perform an in-depth analysis of one particular lesson from this unit. The lesson we chose to analyze was selected because it received the highest level of completion by all students (i.e. 100%), and also contained a knowledge base with substantial levels of idea improvement.

Research Context and Participants

This research was conducted at a university laboratory school in a large urban area. Activities took place within two contexts: (1) in a traditional science classroom with a "bring your own device" (BYOD) policy, and (2) in a specially-designed Active Learning Classroom, which was constructed by the school with the explicit aim of fostering productive collaborations between students.

A purposeful sampling approach was used to select the teacher participant. Selection was based upon the teacher's prior experience in KCI research as well as her availability to design and implement a KCI curriculum during the 2016-2017 academic year. The students who participated in this study were an incidental sample in that they happened to be those who were assigned to the classes of our co-design teacher. Student participants consisted of two sections of a Grade 12 Biology course (n=29), both taught by the same teacher.

Sources of Data

Sources of data for this study included CKBiology design documents (e.g. co-design meeting minutes, lesson planning documents, software mockups), researcher field notes, as well as student learning artifacts and data logs captured by the CKBiology environment.

Part 1: Scripting Idea Improvement

In this section we respond to our first research question: How can idea improvement be supported within a KCI script? We designed a script for CKBiology that included explicit opportunities for idea improvement. The CKBiology script included two major components: *Lesson activities*, and "*review challenge*" activities. During the CKBiology lesson activities, students worked together as a learning community to co-construct a shared knowledge base, oriented around particular lesson topics. The knowledge base took the form of a concept map, with each node representing a student-generated explanation of a particular term or concept (see Figure 1). Near the end of the unit, students applied the community knowledge base towards solving some 'real-world' inquiry challenges (e.g. medical case studies). In this paper we focus on the *lessons* portion of the script only, as this was where construction and idea improvement of the knowledge base occurred.

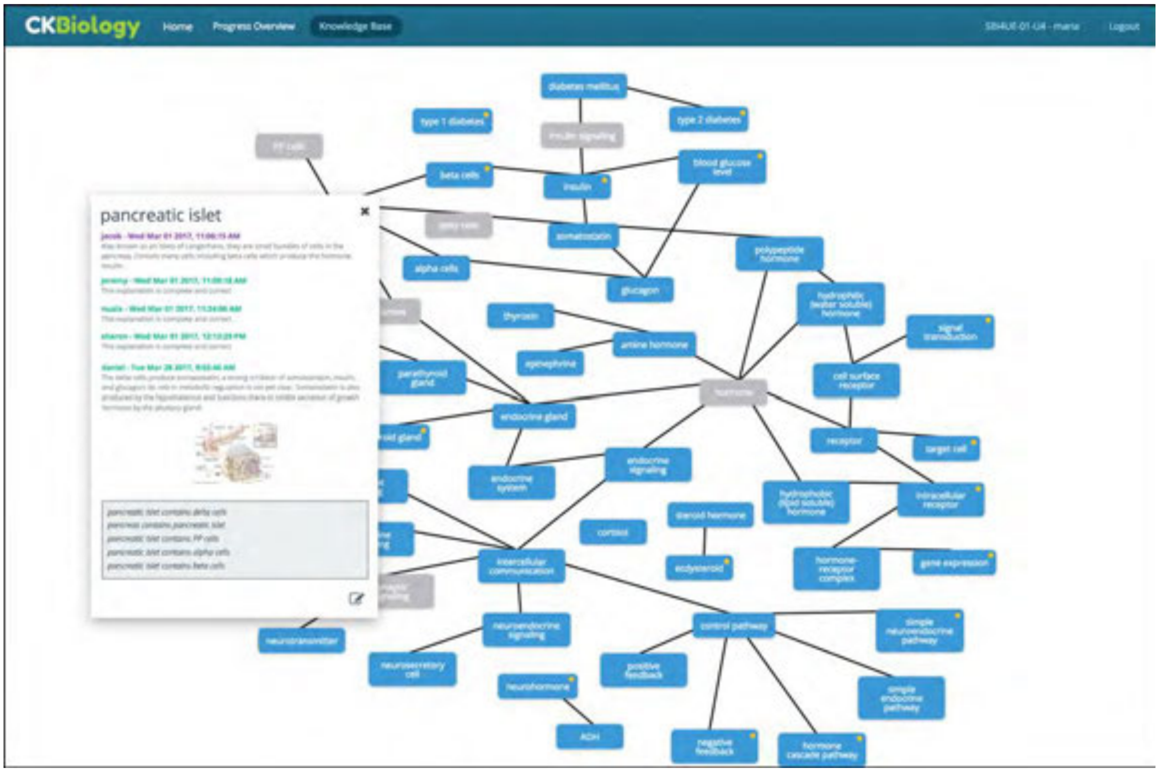

Figure 1. Concept map representation of the community knowledge base in CKBiology. Terms appearing in blue contain completed explanations, while terms appearing in grey have not yet been explained.

The CKBiology lesson activities served to complement traditional classroom lectures, and were performed by students within their regular science classroom using their own devices. In Unit 4, there were eight lesson topics which were taught over fourteen class sessions. Upon logging on to CKBiology, students were presented with the sequence of lessons for the unit, with each lesson activated by the teacher as it was taught (see Figure 2). Upon selecting a lesson to work on, students were assigned three different types of tasks. The first type of task was to *explain terms or concepts* related to that day's lesson. The list of terms associated with a given lesson was established in advance by the co-design team based on the Ontario curriculum expectations, with terms divvied up evenly among all students in the class. Students' explanations for their assigned terms were contributed to the community knowledge base in the form of text-based notes with optional images. On average, students were assigned four or five explanations (i.e. terms or concepts) per lesson throughout Unit 4. The second type of task was to *identify relationships* between terms or concepts in the knowledge base. Within the CKBiology interface, students were presented with two terms separated by a drop-down list of relationship types. In this case, there was actually a 'correct' relationship between each pair of terms, established in advance by the co-design team and programmed into the software. If a student chose the correct relationship, a line would appear connecting the two terms in the knowledge base. The relationship would also appear as a sentence within each note involved in the relationship. For example, the sentence "chloroplast *contains* lumen" would appear in both the "chloroplast" note and the "lumen" note. In CKBiology, students were assigned an average of five relationships per lesson throughout Unit 4.

The third and final task was directed at idea improvement. Here, students were asked to peer review, or "*vet*," explanations that were submitted by other students in the community. Notes were distributed to non-authoring students such that each term received a minimum number of vets (i.e. 6-7 per term). First, students were presented with an anonymized note followed by the prompt: "Is this explanation *complete* and *correct*?" If the student responded "yes," then that student's name would be appended to the note along with the statement "This explanation is complete and correct." If the student responded "no," a text box and image uploader would appear beneath the original note, and the student would be asked to contribute a build-on, submitting any new ideas and/or corrected information (see Figure 3). Any additional information entered by the student would be appended to the original note along with the student's name. Subsequent vetting decisions performed on that note would be appended in the same fashion. Within the knowledge base, a yellow dot was used to identify notes that contained new or corrected information as a result of student vetting (see Figure 1). This yellow dot served as a cue to the teacher to take a closer look at these notes and potentially initiate a follow-up discussion to negotiate these ideas as a class.

Figure 2. CKBiology home screen

Figure 3. Vetting interface in CKBiology

As students progressed through each of their assigned tasks, a progress bar at the top of their screen would indicate the proportion of work they had completed and the proportion of work that remained. Additionally, on their home screen students could see their individual progress bar for each lesson as well as an overall progress bar for the whole learning community. If a student saw that the progress level of the community was below 100%, they could choose to go 'above-and-beyond' their own assigned tasks and make additional contributions to the knowledge base to boost community-level progress. These additional contributions typically took the form of extra vetting tasks, which did not detract from the assigned work of other students. Thus, no single student could dominate the knowledge base by populating an inordinate number of terms and relationships, and every student was still accountable for making their fair share of contributions.

Following the lesson activities, there were two CKBiology *review challenge* activities that were completed by small groups of students within the Active Learning Classroom. The purpose of the review challenge activities was for students to apply their community knowledge towards solving a series of medical case studies—first working as medical specialists, and then working in jigsaw groups (i.e. "medical clinics"), pooling their diverse expertise in order to diagnose a virtual patient with ambiguous symptoms.

Part 2: Analysis of Idea Improvement

Attributes of Improvable Notes

In this section, we respond to our second research question: How do notes in the knowledge base vary with respect to the levels of idea improvement they receive? Within our selected lesson/case, each class section produced a knowledge base containing 31 notes (i.e. terms/concepts). First, we compared the terms containing a "vetting dot" (i.e. indicating that at least one student had improved upon the original explanation) with terms that did not contain a vetting dot. The knowledge bases produced by each class section contained ten terms with vetting dots, however only three of these terms were common between the two classes (i.e. bioenergetics, evaporative loss, and thermoregulation). There were no significant differences in the nature of the terms that contained vetting dots, which represented a mix of concrete nouns (e.g. hypothalamus, endotherm, conformer), abstract concepts (e.g. estivation, acclimatization, bioenergetic strategy), and processes (e.g. thermoregulation, counter-current heat exchange, evaporative loss). As well, terms with and without vetting dots did not differ with respect to the number of relationships (i.e. connections) they formed within the concept map.

Next, we examined the contents of the notes with and without a vetting dot. Overall, notes with a vetting dot contained shorter explanations (M=17.2 words) compared to notes without a vetting dot (M=31.17 words). A student t-test for independent means revealed that this difference was marginal ($p=0.063$). There were four notes for which the written explanation was accompanied by a supporting image. In all four cases, notes that contained an image did not contain a vetting dot. This finding points to the potential utility of visual evidence in supporting students' explanations (Cober et al., 2015).

Finally, we examined the subset of notes containing a vetting dot in order to identify the types of idea improvements they received. Build-ons to these notes were coded as either "new information," "correction," or "redundant." (The "redundant" category was used in cases where it was evident that the peer-reviewer had not fully read the original explanation and simply provided their own, similar explanation). Overall, 73.9% of build-ons were coded as "new information," 21.7% were coded as "correction," and 4.3% were coded as "redundant."

In a follow-up interview, one piece of feedback we received from the teacher was that that it would be helpful to have two distinct vetting dots—one for when a build-on contained new information, and another for when a build-on contained a counterpoint/correction: "*Because many times I went into the yellow dots and there was no conflict. There was just, like…somebody put half the definition and then the second person put the second half of the definition, and then a third person came in and said 'oh wait a minute, and these are examples of blablabla,' which I thought was great… And then you can take it up in different ways.*"

Students' Contributions to Idea Improvement

In this section of our analysis, we respond to our third research question: How do students vary in their contributions towards improving other students' ideas? Within our script, the task of vetting the knowledge base was fairly coercive (i.e. students would not earn 100% until they had performed a minimum number of peer-reviews). Thus, we were interested in determining the extent to which students may have *satisficed* their peer reviews—for example, by declaring all of the notes they reviewed to be "complete and correct" for the sake of getting through the activity. We classified students as "satisficers" if: (1) *All* of the notes they reviewed were deemed "complete and correct," AND (2) if another student contributed an improvement to a note *after* they had already deemed it to be "complete and correct." Based on these parameters, we found that 13 out of 29 students (i.e. 44.8%) showed evidence of satisficing their peer-reviews.

Next, we compared the "satisficers" with "non-satisficers" in terms of their CKBiology progress scores. There were no significant differences in the first class section, however in the second class section students who were "non-satisficers" earned significantly higher progress scores (M=141.2%) than the "satisficers" (M=105.4%; p=0.04). Acknowledging that 100% represents students' *minimum* required contributions, this finding suggests that the "non-satisficers" were more likely to go 'above-and-beyond' in improving community knowledge compared to the "satisficers," who were more likely to complete only their minimum assigned tasks.

Discussion

In Part 1 we presented the design narrative for CKBiology which included scripted moments of idea improvement in the form of "vetting tasks." Here, notes from the knowledge base were distributed to non-authoring students for peer-review. The design of our script could be considered 'coercive' in that students could not proceed in the lesson until they had completed their current peer-review. Furthermore, students would not earn a progress score of 100% until they had completed a minimum assigned number of peer reviews. As identified in Part 2, the coerciveness of this script may partly explain the substantial number of students (44.8%) who "satisficed" their vetting activities. This finding may have been compounded by the high number of peer-reviews that students were asked to complete (i.e. 13 per student) relative to their other tasks. As well, the progress bar representation in the CKBiology interface did not convey the specific *number* of tasks that remained (i.e. terms, relationships, and vetting), with students' progress expressed as a percentage. We therefore acknowledge three opportunities for future work. The first would be to explore how reducing the coerciveness of the script would influence students' vetting activity (for example, by allowing students to select which terms to review). The second would be to understand how students' vetting behaviour changes when the number of assigned vetting tasks is reduced (or increased). The third would be to design progress indicators that provide students with greater awareness of the number of tasks remaining. If students were made aware that they had, for example, only *five* peer-reviews to complete as opposed to thirteen, perhaps these reviews would be completed with greater care and less satisficing.

The satisficing behaviour we observed may also be partly explained by the nature of our intervention. Because our research ethics protocol disallowed assigning grades for participation, we were forced into a position of focusing on activities that were perceived by students as supplementary to their 'traditional' activities (i.e. lectures, worksheets, and tests). We recognize the general need for epistemological coherence within a learning community approach. Students who are situated within an otherwise lecture and test-based course will have a difficult time identifying with and participating in any "community" elements.

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Acknowledgments

This work was supported by the Social Sciences and Humanities Research Council of Canada.

Multi-modelling dialogic skills: The use of multiple resources to support classroom dialogue

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Abstract: Students' dialogic skills can be an important predictor of academic achievement. Thus, it is crucial for teachers to support the development of this specific use of language as a tool to enable understanding of each other's knowledge and perspectives. The integration of other people's ideas into your own thinking enables the possibility of thinking together and constructing new knowledge together. The use of digital technology in classroom activities can support this form of dialogue, but to be beneficial, it requires integration into teachers' practices and task designs. This paper explores how students in a Norwegian 7th grade classroom are taught dialogic skills through their teacher's modelling and explicit focus on the use of language along with multiple resources. The data material is from the DiDiAC-project, which has a design-based approach and is grounded in sociocultural theory. The findings suggest that integrating *Talkwall* in classroom activities increases the possibilities of enhancing participation and making students' contributions visible, thus opening up for the opportunity to build a collective knowledge base to support knowledge building. Through these findings, we hope to contribute a perspective on how the integration of digital technology can support the development of dialogic skills.

Introduction

This paper explores how students in a Norwegian 7th grade classroom are taught dialogic skills through their teacher's modelling and explicit focus on "how to talk," along with the use of multiple resources, including the microblogging tool, *Talkwall*. The analysis is in a preliminary stage, and what is presented here is only a tiny fraction of the research on this teacher's practice. Further work will require a more nuanced and broader perspective.

With the use of an interaction analytical approach, I analyse two excerpts from whole-class discussions. The research question explored in this paper is: 'How can the teacher support students' development of dialogic skills with the use of multiple resources?'

The research reported is part of a larger project called *Digitalised Dialogues Across the Curriculum* (DiDiAC), which focuses on teachers' professional development and the development of new digital classroom practices.

Microblogging in classrooms

The use of digital technology in classroom activities may enhance new forms of dialogue (Rasmussen & Ludvigsen, 2010). However, it is not the technology itself that increases quality in classroom discussions (Rasmussen, Lund, & Smørdal, 2012). To be beneficial, technologies need to be integrated into the teacher's practices and task design (Dillenbourg, Järvelä, & Fisher, 2009). To productively handle the presence of technologies in classroom dialogue, there is a demand for norms and ground rules that are defined and regulated in the context of the classroom (Lund & Rasmussen, 2008; Rasmussen & Lund, 2015; Rasmussen et al., 2012). For dialogues to be sustained, participants must have a mutual perception of what is accepted and what is not (Sacks, 1992). Such ground rules are implicit characteristics for conversations, created to manage situations and interactions in local cultures such as classrooms (Edwards & Mercer 1987; Mercer & Littleton 2007). Studies have shown that ground rules jointly established by students improve participation and the quality of discussions. Thus, it is crucial that the students themselves help develop ground rules through joint reflection, which can lead to a sense of ownership and an obligation to use them (Rojas-Drummond, Pérez, Vélez, Gómez, & Mendoza, 2003).

While there is a body of well-established research on classroom dialogue and talk (e.g., Howe & Abedin, 2013; Mercer, 2008, 2013), there is less in-depth research on the use of microblogs as a *tool for talk*. *Talkwall* (Figure 1) is a microblogging tool developed by researchers at the University of Oslo. It is web-based and was created to promote and support classroom interaction. *Talkwall* draws on the microblogging approach of using only short messages to communicate, using this to encourage students to engage and share their developing ideas, in turn, promoting positive dialogic interactions. Short written texts can be produced either collectively or individually and can later be shared on a digital device. With hashtags (#), text can be sorted in order to make it easier for students to follow specific topics or selected concepts.

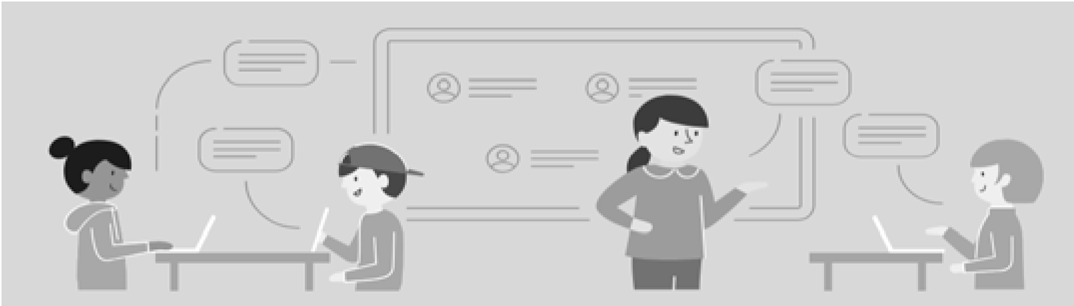

Figure 1: The use of *Talkwall* in classroom interaction

Despite the fact that few studies have examined this type of microblogging in a classroom context, there are findings indicating that the format may enhance engagement and increase participation (Gao, Luo, & Zhang, 2012; Luo & Gao, 2012). Most studies on this type of technology utilise reports on well-established microblogging platforms such as Twitter, which are not designed specifically for conversations. However, some findings show that tweets often help initiate conversations (Gao et al., 2012) and can be used to explore and bring new information into conversations (Thoms, 2012). Research has reported on the benefits of allowing instant feedback and comments, in addition to the main instructions (Li & Greenhow, 2015; Luo, 2015), and an enhancement in academic achievement (Junco, Elavsky, & Heiberger, 2013). The use of Twitter has also been reported to increase on-task talk, the ability to redirect discussions during the activity and the possibility of using the shared representation of tweets to direct final whole-class conversations, which allow for more concrete discussions (Mercier, Rattray, & Lavery, 2015). Luo and Clifton (2017) sought to exemplify how knowledge construction can take place in microblogging-based environments, and they presented a model of Twitter integration into classrooms. Central to the integration of microblogging activities are, for example, exploring hashtags, discussing various topics and participating in live chats, *along* with the primary instruction activity (Luo & Clifton, 2017). This is a type of knowledge-building activity that emphasises knowledge creation in collaboration, while engaged in the microblogging environment, which is similar to the knowledge-building approach presented by Scardamalia and Bereiter (1994). Rasmussen and Hagen (2015) found connections between an increase in subject attainment and the content in microblogs displayed on a shared screen, combined with the students' and teacher's own dialogic elaborations of that content. The microblogs thus made it possible for the teacher to engage with the students' thinking.

When the microblogging tool *Talkwall* is used in the classroom, it creates the possibility to make all students' contributions visible to the whole class; thus, the class can build a collective knowledge base and support knowledge building (e.g., Scardamalia, 2004, 2014), which can be used as a basis for discussion or further development. In this way, the tool can be advantageous in the teaching of dialogic skills.

Teaching dialogic skills

The way in which teachers act and structure classroom activities can make a powerful contribution to student development, both as collective and individual thinkers. For students to develop this ability, they need to be involved in thoughtful and reasoned dialogue (Mercer, 2002). In this work, the teacher can model useful language strategies and, with questions, guide students towards giving reasons and reflections for their views or actions. These strategies can help students in both sharing their views and in modelling how to use language to compare, debate and look at different perspectives. This type of experience is something students can get from dialogic teaching (Mercer, 2002; Mercer & Littleton, 2007). The teaching is dialogic when both teachers and students make substantial and significant contributions, and there is a means of advancing students' thinking on an idea or theme. According to Alexander (2004), this type of teaching is intended to highlight the ways in which teachers can encourage students to participate actively by supporting their ability to articulate, reflect on and modify their understanding.

When students are taught dialogic skills, they perform better in critical thinking, collaborative problem solving and reading comprehension (Howe & Abedin, 2013; Kuhn, 2015; Lawerence & Snow, 2010; Mercer, 2013), and one important predictor of students' learning appears to be the quality of classroom discussion (Gamoran & Nystrand, 1991; Murphy, Wilkinson, Soter, & Hennessey, 2009). Dialogic skills refer to a specific use of language, used as a tool to enable understanding of each other's knowledge and perspectives. It is a way of reasoning, which creates an understanding based on one's own perceptions, while allowing other ideas and opinions to adapt or integrate into one's own thinking. Participants in dialogue – in this case, conversations with a particular purpose and character – can think together and construct new knowledge together (Mercer, 2000). This type of collective knowledge creation bears similarities with the knowledge-building perspective introduced by Scardamalia and Bereiter (1989). Knowledge Forum (Scardamalia, 2004), a technological platform that builds on the knowledge-building concept, is an environment that supports work with ideas in collaboration. This is an environment in which participants have the possibility to solve problems and reason collectively by building on each other's notes and where others can criticise or contribute to the improvement of ideas. *Talkwall* builds on a similar intention, and the technology supports the production of collectively created ideas and the possibility of contributing to the improvement of others. In addition, *Talkwall* can support face-to-face classroom interaction, with its hybrid characteristics and the possibility of organising ideas, in both a timely and spatial manner.

From a socio-cultural perspective, the role of classroom dialogue has a significant impact on how we understand students' knowledge structure, and students can be taught how to make effective use of spoken language as a cultural and psychological tool. Despite the fact that research clearly shows a connection between the quality of classroom discussion and school development (Alexander, 2012; Mercer, 2013; Mercer & Howe, 2012), some findings suggest that such discussions rarely occur in the classroom (Applebee, Langer, Nystrand, & Gamoran, 2003). In many cases, teachers who believe that they facilitate rich discussions are often, in reality, simply using the well-known Initiation-Response-Feedback (IRF) structure (Cazden, 2001; Wells, 1999). This three-turn sequence is well documented in the educational literature and is both recognised as having an important role in guiding students' learning (Mercer, 2002) and criticised for favouring teacher dominance in the dialogue (Lemke, 1990). It has also been recognised by researchers that the three-turn sequence assumes a diverse role and complexity, which is neither positive nor negative, but that its value depends on the purpose it is meant to fulfil (Erickson, 1992; Lee, 2007). According to Lee (2007), the third turn in the IRF structure, the teacher's evaluation or feedback, represents an extraordinary space, in the sense that it puts forward the unforeseen variety of actions carried out by the teacher, depending on the students' second turn. This third position turn can be used to perform complex pedagogical actions such as steering the direction of a sequence or making hearable or visible the focus of the teaching point (Gardner, 2013). Teacher reformulations in classroom interactions have received attention within educational research. According to Mercer (2002), teachers often rely on techniques such as *recaps* or reformulations to, for example, making links between the past, present and future, which can help students build new understandings beyond the foundations of their previous learning. In addition to supporting students' sense-making, the teacher, by encouraging students to draw on, for example, the expertise of previous activities, can also *help students learn how language can be used as a tool for making joint, coherent sense of experience* (Mercer, 2002).

In this paper, the focus is on teaching design and how students can be taught dialogic skills through the integration of the digital technology tool, *Talkwall*, alongside the use of various resources used as structuring tools in the classroom. What this study seeks to explore is the multimodal aspect and integration of the multiple resources in the task design.

Data and methods

The DiDiAC project has a design-based approach based on collaboration between teachers, researchers and technology developers. All the interventions in this project take place in the classroom context, and interventions and tools develop in interaction with practice (Anderson & Shattuck, 2012). The data consist of video from classroom situations, audio recordings of interviews and classroom observations. The material from the teacher, used as an example in this paper, consists of three hours of research lessons in the subject 'Norwegian language and literature' in a primary school class of 11-12-year olds. After examining the data, there were several occasions in which the teacher quite explicitly focused on the students' way of using talk as a tool for learning. There were also numerous situations in which *Talkwall* was used to recap or reformulate the students' contributions in the whole-class discussions. To present central aspects of the diverse use of *Talkwall*, I have chosen two excerpts for the present analysis and will explore how the teacher used reformulations to support and focus on the students' development of dialogic skills through the use of an interaction analysis (Jordan & Henderson, 1995) of these excerpts. To capture not only what is said, but also details of how something is said, such as visible behaviours and other features of the delivery of talk – which is a key insight of interaction analytic research (Hepburn & Bolden, 2013) – Jefferson (2004) developed detailed transcript conventions for representing talk. In this paper, the transcripts include only the most central details for this level of analysis, such as overlaps and gestures.

Analysis

To present some of the ways in which this teacher integrates multiple resources in order to focus on the development of dialogic skills, two excerpts from the same class were used as examples. The class created ground rules for talk as part of the project intervention. The students were explicitly taught about *exploratory talk*, which is a way of interacting that emphasises reasoning, the sharing of relevant knowledge and a commitment to the collaborative endeavour (Mercer, 2002). The class and teacher agreed on a set of ground rules for talk. The ground rules are examples of suggested strategies used as scaffolds to promote dialogic skills (Rojas-Drummond et al., 2003). The class agreed on these rules by choosing and discussing what they found most important from a list of suggestions. The rules were made visible to the students in several ways, for example, they were written on posters that were always visible to everyone in the classroom or were shown on the whiteboard during group discussions. They focused on two-three rules at a time. In this lesson, the focus was on *being a good listener* and *building on* *each other's ideas*. In different ways and situations, the teacher reminded the students about these rules on several occasions during the lesson. For example, she pointed to the rules on the wall, physically moved the posters with the rules closer to the students and made mention whenever they followed the rules. When the students worked in groups, they were usually in groups of three and were encouraged to use exploratory talk when they worked with the different activities. The teacher in this class acted as a model and guide for the use of exploratory talk. She also used reminders to support the talk both in groups and whole-class discussions and prompted the students, both in writing and orally, through digital or analogic means. The analysis of the two excerpts are structured as following: a) description of the context of activity; b) excerpt text; c) description of the interaction and d) description of the teacher's strategy.

Reformulating dialogic skills

In this episode, the teacher is making the dialogic skills explicit through reformulations. The following excerpt (excerpt 1) is from a whole-class discussion in which the teacher and students discussed whether or not the words they were focusing on had a negative or positive meaning. The task was an exercise for subsequent work on writing speeches for two different famous people. The teacher wanted the students to reflect on the context in which words occur, to whom the words are supposed to communicate, who the talker is and so on. This was followed by a whole-class discussion in which the teacher asked the students what they thought about when they heard the expression 'little trolls'. Before the ensuing discussion, the students discussed the words in groups of three. This excerpt is from a student's contribution to the whole-class discussion about the different meanings words can have.

Excerpt 1: Making dialogic skills explicit trough reformulations

```
Teacher:  Andy wanted to say? ((points to Andy))
Andy:     Im thinking in a way that little trolls can be an
          positive, because let's say that elderly people can
          say-  they or uh grandmothers, grandparents can
          say it like what's it called just express it
          positive. [but
Teacher:            [Yes.
Andy:     Maybe other people when they say that to you maybe they
          mean something negative. [But
Teacher:                           [Uhm
Andy:     I believeit can be both.
Teacher:  Mhm. Now you are building on what both Camilla and Lina said
          right? Elaborating on what they said. ((points at the
          Camilla and Lina))
```

In this student contribution, Andy first expresses that the word can be positive and proceeds to provide an example of this about how grandparents can use it in a positive sense (lines 2–6). He then adds that 'other people' can say this in a negative way (lines 8-9) and concludes with his own opinion that it can embody both meanings (line 11). The teacher then makes a point of Andy's contribution as building on what others had said before him (referenced as Camilla and Lina in line 12) and that he is also *elaborating* (lines 12–14). This is a method of reformulation that references the ground rules of talk, which the class had focused on for a long period of time. The teacher recognises the students' contribution as important to the whole class, but instead of giving feedback on the content, the feedback relates to the way in which the student is making his contribution. By uttering "mhm" (line 12), she is confirming that he is right, but instead of using this third turn to elaborate or summarise, she is elucidating to the whole class that what Andy has just done was to build on and elaborate what others had said before him.

This was a typical strategy used by this teacher throughout the material. She explicated, pointed out and modelled dialogic skills for the students in different situations, using multiple resources. The excerpt shows her using a reformulation to reference the student's contribution as more than just the subject-specific goal. The teacher, in addition to approving the student's answer, explicates to both the student and the whole class what the student actually does – he *builds on* and *elaborates* (lines 12–14), which goes back to the beginning of the lesson where she reminded them of the rules of talk. Other strategies used by this teacher to model dialogic skills included referring to posters on the wall or through the use of *Talkwall* contributions. The teacher's way of making the elaboration and building on each other's ideas, visible through language or other resources, plays an important role in guiding the students' learning of dialogic skills (Mercer, 2002).

Making ideas available through Talkwall

In this episode, *Talkwall* opened up the possibility of building on each other's ideas. The next excerpt is from a lesson in which the students were taught about the differences between an opinion and a fact in the subject 'Norwegian language and literature'. For homework, the students contributed to *Talkwall* five things that they cannot live without. Back in the classroom, the students were discussing the *Talkwall* contributions in groups of three. The group task was to hashtag the different contributions with #opinion or #fact. Before the group could do this, they had to engage in discussion, and the teacher pointed out questions they were supposed to ask each other in the groups. The questions were ‘Why do you think that this is a fact?’ and ‘Why is this an opinion?’ These questions were visible on the whiteboard throughout the group discussion. When all the groups had hashtagged the *Talkwall* contributions, the teacher started a whole-class discussion (Figures 2 & 3). One group hashtagged #clothes as an opinion. The teacher asked the group to elaborate on why they chose the specific hashtag and what they discussed the most.

Figure 2: *Talkwall* on both students’ ipads and on the whiteboard

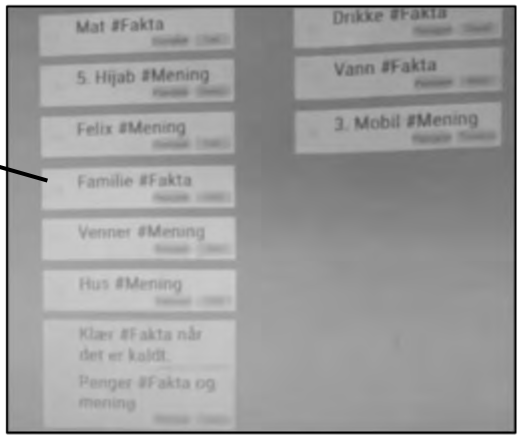

Figure 3: Student contributions on *Talkwall* with #fact or #opinion (Norwegian; #fakta #mening)

Excerpt 2: Using Talkwall as a starting point for building on the ideas of others

```
Teacher:  Clothes. Yes, Yes. Tell us about this.
Lina:     Because, if no one in the world had clothes then it
          would not be like it would be strange.
          But you would survive without clothes. But we could say that it
          is a fact because clothes are something that we use to
          protect the body. So, it depends a bit on where you live
          in the world.
Teacher:  Yes. Good. Cindy, did you have a comment to this?
          ((points to Cindy))
          (1.0)
Cindy:    Uh I think clothes is a fact because you need clothes. But
          you can cover yourself in a plastic bag. But you cannot
          run around naked. You need clothes to cover the body. To
          protect it from snakes and so on.
```

In excerpt 2, the student groups posted their contribution to *Talkwall*, and the teacher asked a group to share the topic that they had discussed the most. One group member responded that it was clothes. The teacher then displayed their *Talkwall* contribution on the whiteboard and encouraged her to tell the whole class about this discussion (line 1). The student then pointed out that clothes could be an opinion because you can survive without them, but conversely, they could be a fact because we need to protect the body. The student then concluded that it depends on where you are in the world (lines 2–7). In *Talkwall*, the group wrote that they are a fact when it is cold. The contribution was displayed to the whole class on the whiteboard, and other students signalled to the teacher that they wanted to comment on this contribution. The teacher selected one student to comment, who said that clothes are a fact because you cannot run around naked (line 13) and that you need clothes to protect yourself from, for example, snakes (line 14). Thus, the student in this turn elaborated on what the other student had said and *built on* the *Talkwall* contribution.

In this excerpt, the teacher used the third position in the IRF structure to include other students to comment on the *Talkwall* contribution. What the student then did was to build on the ideas expressed in the contribution and elaborate on the reason that clothes are a necessity. *Talkwall* was a central starting point for the discussions in this activity, both in the groups and the whole-class discussion. In the group activity, the students discussed and agreed on how to hashtag their opinions about the five things they could not live without. In the whole-class discussion, the groups’ contributions were available for everyone to read; thus, they had the possibility to read all the opinions of their peers. One of the rules of the lesson was to build on each other’s ideas. The *Talkwall* technology made this possible by reifying the students’ ideas in written text, thus making the contributions visible to all and available to build on.

Conclusion and further research

This paper explored how students in a Norwegian 7th grade classroom are taught dialogic skills through their teacher's modelling and explicit focus on *'how to talk'*. Through an examination of two excerpts, the paper sought to allude to examples of a practice that can enhance the development of students' dialogic skills. By paying attention to the third position in the IRF structure, this paper explored the usefulness of the third turn in, for instance, making visible the focus of the teaching point, such as explicating how to build on each other's contributions (Gardner, 2013).

Another aspect was how the microblogging technology can be integrated as a resource to elucidate both how to build on each other's thinking *and* to enhance engagement and increase participation (Gao et al., 2012; Luo & Gao, 2012). The technology in the microblogging tool *Talkwall* opens up the possibility for more students to participate, thus increasing the potential for building on the ideas of others. To be beneficial, the use of technology in the classroom needs to be integrated into the teacher's curriculum and task design (Dillenbourg et al, 2009). *Talkwall* mediates in a hybrid manner, a combination of oral and written contributions, which permits the tool to be integrated with the task design and allows for other resources to be included. In the examples presented in the analysis, the teacher's role of modelling the use pf multiple resources represents how students can be taught dialogic skills. The teacher in this study used *Talkwall* as a tool to support both whole-class and group discussions. The way it was used in this teacher's practice illustrates the potential of using this type of hybrid tool because it can be integrated into face-to-face discussions and enhance the dialogic aspect of the activity.

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Learning from the Knowledge Builders: Students Making Sense of the Change to a Classroom Knowledge Building Community

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Abstract: How do students make sense of the change process from more traditional learning environments to a knowledge building classroom? How do they understand their own participation and the development of the collective as a knowledge building community? This research follows a team of middle school students and teachers over the course of two years. The teachers had been engaged in developing knowledge building classrooms for eight years, while the students were new to the approach. Student interviews collected across the years are used to engage students in meta-discourse around their community's knowledge work in the Knowledge Forum database and their development as knowledge builders. The findings contribute to a growing body of work examining student socialization into knowledge building communities.

Introduction

"Change is hard" is a well-known maxim. Creating classrooms that function as *knowledge building communities* (KBC) is challenging since it involves teachers and students engaging in modes of inquiry foregrounding student agency, the progressive improvement of conceptual artifacts, and collective knowledge advancement, which is radically different from the ways in which teaching and learning occur in more traditional classrooms (Scardamalia, 2002; Scardamalia & Bereiter, 2006).

There have been several studies detailing teachers' experiences as they transition to classrooms that function as knowledge building communities (e.g., Caswell & Bielaczyc, 2002; Hewitt, 2002; Messina, 2001; Zhang, Hong, Scardamalia, Teo, & Morley, 2011). Studies of students in KBC classrooms have provided important insights into how students work to build knowledge in the Knowledge Forum (KF) database (e.g., van Aalst & Chan, 2007; Tao & Zhang, in press; Zhang, et. al, 2011; Zhang, Scardamalia, Lamon, Messina & Reeve, 2007) and the impact of knowledge building on learning content knowledge (Chan, Lam & Leung, 2012; Scardamalia, Bereiter, & Lamon, 1994; Zhang, et. al, 2014). However, if we are to expand our understanding of how to support classrooms in transitioning to knowledge building communities, we need to expand this body of work to include detailed investigations of how students themselves experience such shifts. In the present paper, I investigate what students have to say about how they navigate these transitional experiences and the insights that they provide into their socialization as knowledge builders.

Research Context and Methodology

This investigation focuses on students of the Whitman Team, a team of middle school teachers that sustained their creation of KBC classrooms for over 8 years with very little external support (Bielaczyc, 2006, 2013; Bielaczyc & Collins, 2006). Whitman Middle School is a suburban school in the Midwest United States serving approximately 600 students in grades 6^{th}-8^{th}. During the period of the research reported here, the Whitman Team worked in 4 classrooms of roughly 25 students each. The teachers and students stayed together for two school years, starting in 6^{th} Grade when the students first came to the school and continuing through 7th Grade. Knowledge Forum was a part of the learning environment throughout the entire two years. There were three research units across each year (e.g., World Religions, Astronomy). The teachers gave each unit the same basic structure: (a) focusing on problems within the research topic, (b) carrying out sustained investigations for 8-10 weeks, and (c) working in the database and face-to-face toward building a shared understanding.

The research at Whitman Middle School was conducted over the course of one and a half academic years. Beginning in the Spring of the 6^{th} grade year and continuing until the end of the 7^{th} grade, I visited roughly every 6-8 weeks. The visits took place over one school week. Each visit typically involved interviewing students and teachers, spending time observing classes, and talking with the principal and other school community members.

The student data collected over the course of the visits was exploratory in nature. Here I focus on student interviews conducted across both years. In each interview, the student logged into Knowledge Forum and the database was used as a dialogic tool in order to engage students in meta-discourse around their community's knowledge work and their development as knowledge builders.

Because the interviews would only involve a small subset of the Whitman Team students, it was important to hear from a variety of students. Teachers also requested "that different student voices be heard." Based on their observations over the years, the teachers felt that student participation may be differentially impacted by student ability in verbal and written expression. Prior to the first set of interviews in the Spring of the 6th grade year, the teachers created a chart placing students on the team into three groups: *High Literacy* (HL), *Medium Literacy* (ML), and *Low Literacy* (LL) based on students' scores on the Iowa Test of Basic Skills along with teacher judgments of verbal expression. The interviews were conducted with students chosen from across the three groups. Multiple interviews were carried out in 6th and 7th grade. Each interview drew from the same basic set of questions, with students' responses leading to variations in follow-up questions. Most interviews were 40 - 60 minutes in length. The interviews were audio-taped and video-recorded, with the audiotapes transcribed. Five interviews had technical problems in the recording. The resulting corpus contained 52 interviews, with a group distribution of 10 HL students, 11 ML students and 10 LL students (designated alphanumerically in the text below).

Analyses

The goal of the analyses was to investigate how students navigated the shift to a KBC classroom, and to develop a feel for the landscape of student experiences over time. Through focusing on the students' narratives, the intent was to better understand how learners come to participate in a culture of inquiry and are socialized as knowledge builders.

One of the major findings was the emergence of four specific elements that students found particularly influential in their own participation and the development of the collective as a knowledge building community:

- the structure provided by the research cycle (supported by the Knowledge Forum scaffolds),
- the public visibility of student work in the Knowledge Forum database,
- the norm of shared responsibility for the work, and
- interactions with persons outside of the classroom context.

Further, the data indicated that each element had the potential to help or hinder student transitions. That is, the influence varied across students, with some students seeing the element as a support to navigating the change to a knowledge building community, and others seeing the element as a potential barrier to participation. In many cases, the difficulty experienced by the student (i.e., the discomfort in having their work on public view or the desire to work alone) abated over time, as the new model began to function more smoothly with more and more students engaged in knowledge building work.

Given space limitations, here I elaborate student perspectives on two elements (see Table 1). The first element, *the public visibility of student work in the Knowledge Forum database*, is chosen because it is central to the principled design of the KBC model. The second element, *interactions with persons outside of the classroom context*, is included because it has not been discussed broadly in the KBC literature. Therefore, student perspectives on this element may help deepen teachers' and design researchers' understanding of the roles persons outside of the classroom can play in enacting KBC classrooms.

Public Visibility of Student Work in the Knowledge Forum Database

The Whitman students spoke of how having the work of the entire community in the public space of the KF database provided models of inquiry for them to learn from. For example, student HL-6 pointed out that seeing others share their "crazy" ideas can make one less "timid" to contribute one's own ideas to the database: "And say, like, if you have a theory that you think is totally crazy, but then you see that tons of people have the same kind of ideas, you may not be as shy or timid to stand out." Student LL-3 describe how she adopted particular processes that she saw modeled by others. Specifically, she talks of how seeing the use of the research cycle in the KF Notes of peers led to her own adoption of the structure:

> LL-3: When I first started Knowledge Forum, I really didn't get the, like, what all this stuff meant on the research questions. I really didn't know what they meant, like the *Plan* and the *My Theory* and the *INTU*.
>
> Bielaczyc: And then how did you learn what they meant?
>
> LL-3: Well, really, after I read all the other people's Notes, I kind of just copied what they did. And, 'cause at first I put all my understandings and all my learnings and everything under *New Learning*'s. Last year I did that, when we first had our first thing. And then, after I read other people's Notes, and then, after we did our second, like, Knowledge Forum thing, I did what they did and tried to catch up with them on how to understand this, and then I finally did.

TABLE 1: Two influential elements in participants' development as a knowledge building community.

Influential Element	Potential supports described by students	Potential challenges described by students
Public visibility of student work in the KF database	• Provides models of inquiry • Fosters an appreciation of peers • Promotes attention to audience	• Provokes behaviors in service of "looking good" • Limit reading to pre-determined groups (e.g., friends) • Time needed for quality models to develop
Interactions with persons outside of the classroom context	• Positions students as investigative researcher/expert to others • Provides opportunities to explore connections between their KBC work and "real world of work"	• Push back from those who disagree with the KBC model • Discomfort with differences between their work and the work of students from other classrooms

Through seeing the work of other students in the database, students also indicated that they came to appreciate the efforts and understanding revealed in the work of their peers. For example, student HL-6 described how working in the KF database led to an appreciation that "other people have really good ideas." Through gaining an appreciation of their peers, students may become more motivated to read around the database and to draw on the work of others.

The public nature of work in the KF database also meant that students become aware of students who do not make many entries in their Notes or contribute to the work of the class. Thus, students develop an awareness of multiple ways that their peers are working in the database, from students who provide useful inquiry approaches, to those who contribute varying viewpoints, to those who may not participate much in the online space. In this way, they are able to develop a feel for how "we as a class" are approaching the work with knowledge over time.

In addition, students described various ways that they attended to the audience of their Notes. This included student HL-3 describing how she wants readers of her Note to know that it contains "good information." Student HL-8 talked about pride in teaching others through his work in the database. In addition, he detailed the particular methods he employs to attract readers to his Notes and to help them to more easily "grasp the big understanding."

One challenge raised by students in having their work visible to the entire class concerned the desire to "look good." Below, students HL-7 and HL-4 describe their discomfort in putting theories into the database unless they are "right or mostly right." Student HL-4 describes how she even created "fake" theories by using information that she had already gained from her research to go back earlier in her research cycle to add in a "My Theory" scaffold:

HL-7: That's why the teachers are like, "don't be scared to put in what you know." 'Cause I think it still does happen. I mean I can even 'fess up and say that I sometimes won't put in all my theories unless I'm pretty sure, certain, they're right. And I'm sure I should be putting them in, you know, even if they're wrong. I think I'm not the only one. And I think I am, you know, I mean it's hard to not do it because of the whole subconsciously thinking, you know. That's it. And I have to be right, 'cause if I don't it scars my thinking.

Bielaczyc: OK, so why don't you say a little bit about what a "true theory" is and what a "fake theory" is.

HL-4: Well, I did this last year. Last year I'd enter in, I'd go downstairs and I'd like research, then I'd come up here and I'd write a question that would go with what I had already researched. And sometimes if I decided to I'd write in on *My Theory* that would be right or mostly right or personally right or whatever, but theories are supposed to come before your research. So, if it's a real theory it's before you know what's going on.

It should be noted that the behavior of faking theories was described by students as occurring during the 6th grade year, but it was not raised as an issue during the 7th grade year.

Another challenge revealed by the interviews is whether students take advantage of the opportunity to read across the multiple entries in the database, or whether they limit their reading to a pre-determined group of students. In the interviews, several students described a tendency to read Notes from friends or specific students that they knew. If students are limiting their reading to a pre-determined group of peers rather than reading across the database, then they may fail to access the full range of resources available in the database. Further, they may miss the opportunity to re-shape their pre-determined notions of who someone is as a learner based on close examination of their work or through engaging in online interactions with this peer.

Another challenge not explicitly described by the students, but implicit in the interviews is that when the students are just getting started then the number of quality models of inquiry in the KF database may be quite low. This is implied in student descriptions of how it is much more interesting to read around the database in 7th grade in contrast to in 6th grade and when they talk of how their work in the database has improved over time. For example:

> HL-2: Yeah, because at first when we did Knowledge Forum, people really were kind of confused at what to do. They didn't put a lot, they hardly put any theories in. They just put what they thought about like of the book. Maybe they didn't put predictions in or they didn't put questions in. .... Well I think they put a lot more *New Learnings*, like compared to like when we did our first animal topic. ... And I think they did better on questions, they've done a lot better on the questions, making questions up. Because you're not really, at the beginning you don't really work hard on questions. As it is when you've learned before you don't think of questions you just answer the questions that other people think up for you. And, so, they've done better on the questions because they've learned more about doing it.

When the students first begin in 6th grade, they are not joining an existing knowledge building community. Further, at the start of each unit the KF database is empty. The database content builds as the students themselves generate all of the entries. In the early stages, when the work in the database is generated by students who are all new to the KBC approach, the public visibility of the work of one's peers may not yield many helpful examples to learn from.

Summary

Students on the Whitman Team contributed Notes, made Build-On's, and engaged in Discussion Notes in the shared space of Knowledge Forum. Their contributions were publicly visible and accessible to their peers. Students described how the public nature of the work provided multiple models of inquiry, fostered an appreciation of the work of their peers, and promoted students' attention to the audience of their work. The interviews also pointed to challenges raised by public visibility such as provoking behaviours related to "looking good," limiting one's reading to a pre-determined group of peers, and that, in the early stages of a classroom learning to function as a knowledge building community, there may not be many high-quality exemplars in the database.

One of the key reasons that the public visibility of work in the Knowledge Forum database may help in socializing students as knowledge builders is that it permits learners constant access to the processes of knowledge building engaged in by members across the community. It is much like continually playing card games as "open hands" where players make visible their cards, their strategies, and the resultant interactions and outcomes. In contrast to only seeing the final artifacts or polished products of inquiry, students are able to see how the work unfolds over time. In Knowledge Forum, knowledge building processes are made visible through both individual actions and interactions among participants in the database. This may help promote an understanding of not only how to work with one's own knowledge, but how to work in collaboration with others to advance knowledge. Further, students may be able to see not only positive exemplars, but also examples of knowledge building moves that do not lead to success. Such contrasting cases permit differentiation and may support the development of richer understanding (Bransford, Franks, Vye, & Sherwood, 1989; Bransford & Schwartz, 1999).

As an indication of the power of the public visibility of student work in the KF database, student ML-4 pointed out that next year's 6th graders might learn "what it's about" to be part of a KBC classroom if they were shown his cohort's 6th and 7th grade databases: "Well, I think they, like, we saw our reflections from last year and see how much they've changed and, like, how much information we found and our different processes this year from last year. And maybe they'll show the kids next year, like, what it's about."

Interactions With Persons Outside of the Classroom Context

Students spoke of many interactions with persons outside of the classroom context as having a positive influence on their work. For example, students enjoyed conducting interviews with persons associated with their research area (e.g., nurses connected with health research, religious leaders connected with world religions research) and being themselves positioned as experts in taking parents on tours of their work in the KF database during Parent Nights at the school. Several students also noted similarities between their own work as knowledge builders and the work of others outside of school. For example, student ML-9 connected working collaboratively in the KBC classrooms with his father's workplace: "'Cause like when we get like a job and everything, we're not just going to be working all by ourselves. We're going to have to work on a team. Like, at my dad's work, they have this big area. They all have their own little cubicles, but they communicate with each other. They have to, or else (inaudible) to the power plant will melt down."

Persons outside of the classroom context also expressed perspectives that had a negative impact on students' perceptions of the KBC approach. For example, while interviewing student ML-4 at the end of 6th grade, he talked about changing teams the following year. He described how his family had heard rumors about students in the KBC classrooms:

> ML-4: Well, from, no offense to Knowledge Forum, or the teachers or anything, but my friend's mom is a teacher at Franklin [High School] and the kids that were in Knowledge Forum have a horrible listening skill.
> Bielaczyc: Yeah?
> ML-4: And research skills. But I don't…
> Bielaczyc: Mmm, why would they have poor research skills do you think?
> ML-4: I don't know. That's just what my friend's mom told me.

However, when I returned to visit in the 7th grade year, this student had not changed teams and was still part of the knowledge building classrooms. In his 7th grade interview, he described how he enjoyed interacting with others, read up to 50 Notes in the database per unit, regularly participated in Discussion Notes, and felt "special" because he was on a team that got to use Knowledge Forum. At one point in his 7th grade interview, ML-4 referred again to the rumors that he had heard:

> Well, there was really rumors, I don't know if they're true. In high school one of the girls that was on the team last year switched. And her mom said that the kids that learned Knowledge Forum here, when they went up to high school they had poor attention disorders. Like, I don't know how that was, but she said all the kids on the other team are more challenged. But I kind of don't think that's true because we, it's true that we do like, miss one of our classes a day to work on Knowledge Forum, but it's helping us learn how to use reference materials more. And how to use the computers. Because not all, you could go up to kids on the other team that don't work on computers six times a day like we do, and ask them how to open up the internet and how to search things if they haven't had computer skills or anything yet. Which is, like, normal, that no one would know that, but now we have computer skill classes. But since we work with all these things, we're kind of more experienced.

Another negative influence from outside perspectives on how students perceived the KBC approach was expressed as a concern about not following the same curriculum as the other 6th/7th grade team at Whitman. The student worried that the other 6th/7th grade team will "get more accumulated information about many topics":

> ML-7: Because we need to know about more things than like what we're learning, like in Knowledge Forum. Like, the other team will go in more depth about more things than us because they spend, they might not spend as much time, and they might not go as deep as we do, but they still get, they still get more accumulated information about many topics than we do on one.

The school had two parallel 6th/7th grade teams, with roughly 100 students each. The four teachers on one team worked to create a KBC classroom. The other team used a more standard curriculum. Both of the 6th/7th grade teams looped, while the 8th grade year involved classrooms that combined students from both teams. The concern raised by this student centered on how a focus on depth over breadth meant that they did not cover certain subject matter that would be covered by the other team, thus leaving them "behind" when students from both teams entered into 8th grade. (It should be noted that this worry was also expressed in four responses to a survey given about the students' experiences in KBC classrooms at the end of 7th grade).

Summary

Students on the Whitman Team interacted with outsiders to the classroom in a variety of ways. This included interactions with parents at home or during Parents' Nights at the school, with other teachers and students throughout the school day or afterschool, and with persons connected with their area of research as part of the investigative process. The student interviews revealed that such interactions often positioned the students as an investigative researcher, or even as an "expert" to others, thus communicating that their work mattered. Through such interactions, students also described how they saw connections between the way that they worked as knowledge builders and how people in the world worked. The interviews also pointed to challenges that arose in some interactions with parents and other teachers at the school in the form of push back and not valuing participation in a KBC approach. The presence of two 6th/7th grade teams, one functioning as a KBC classroom and the other functioning more traditionally, appeared to contribute to a comparison of the two approaches, resulting in some negative perspectives on participating in knowledge building.

One thing to note is that in the students' 8th grade year, I returned to the school to conduct a follow-up visit. During this time, I met with the 8th grade teachers as a group to discuss the work. In the meeting, the teachers discussed how it was usually clear to them which students were from the KBC classrooms. Many of the 8th grade teachers described how these students tended to question the things that they were told, and that they did not possess the same knowledge and skills that the students from the other team had. One teacher commented "those kids don't know how to do homework sheets." The emphasis in the 8th grade classrooms was on "working independently" to complete written assignments, collaboration and discussion was discouraged. The 8th grade teachers felt that a focus on solo work and report writing was necessary to prepare students for what would be expected of them in high school.

I spoke with several of the students that I had interviewed across 6th and 7th grade about their 8th grade experiences. Many described how their teachers criticized the KBC classes, and publicly unfavorably compared them to the students coming in from the other 6th/7th grade team. When asked about this, the Whitman Team teachers involved in the KBC model described how the 8th grade teachers often openly criticized their preparation of the students for 8th grade. However, they also made it clear that they had a very different set of values about what children should be learning as compared to both the 8th grade teachers and the teachers on the other 6th/7th grade team (the values and teaching objectives of the Whitman Team teachers are detailed in Bielaczyc, 2013). Certainly, it is understandable that non-participating teachers and the parents of both students who are participating in an intervention and those who are not can become sensitive to the implications of non-participation. The points raised here highlight that the impact of interactions with those outside the classroom on student change processes is an area deserving further investigation.

Conclusion

My intent in this paper was to investigate what students have to say about navigating trajectories of change to KBC classrooms. The work focused on students who participated for two years in classrooms facilitated by teachers recognized for their work in knowledge building. This research, along with other studies focused on students' classroom discourse in science inquiry classrooms (Herrenkohl & Mertl, 2010) and student reflections on self-generated inquiry structures in KBC classrooms (Tao & Zhang, in press), contributes to deepening our understanding of how students are socialized as knowledge builders.

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Citizens in the making: An Interdisciplinary Knowledge Building Approach in Citizenship Education

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Abstract

Beyond the pursuit of academic excellence, educational institutions act as an essential focal point in developing and instilling national consciousness and commitment among its youths. With a changing demographical climate and the learning style of the youths, innovative pedagogical approaches to citizenship education needs to be established. In Teck Whye Secondary School (Singapore), our current Secondary Two students (age 14) undergo our signature Heritage Curatorship and Immersion Program as part of their Citizenship Experience. Anchoring on the Knowledge Building principles and its' pedagogical practices, students are to curate a thematic community heritage trail and in the process generate a group song and/or products as a gift to the community. Above and beyond the growth in the depth of their respective disciplinarity understanding of the associated subjects, our findings have shown how our students have in the process become a more collaborative, participative, inclusive and innovative individual—trademark of an active and concerned citizens of tomorrow. This paper seeks to trace and analyse the development of this inventive interdisciplinary Knowledge Building approach from its conceptualization to implementation for a control class of mixed abilities in the context of citizenship education.

Introduction

More than the mere knowledge acquisition of political literacy and theoretical debates between civics and human rights education, an effective citizenship education entails the acknowledgement of the "horizontal relationships" (Frederick Cooper, 2018) where students recognized that they are being connected horizontally to the other citizens through everyday interactions and experiences. As such, educating for citizenship needs to be community-orientated and grounded in the theories of constructivism. Situated within this active community-orientated approach lies the need to weave in a cross-disciplinarity curriculum to facilitates a more realistic and authentic learning environment bringing forth deep and meaningful experiential learning outcomes (Maitles, H. 2005).

In the context of Teck Whye Secondary School, its' neighbourhood is witnessing the increasing proportional representation of the Silver generation in the town's population demographic data. In addition, traces of its' past are not being rigorously studied, captured and/or archived despite it being the first town established in the constituency. Considering the urgency and need for immediate documentation for the community, the school conceptualized the Heritage Curatorship and Immersion Program (HCI). This program aligns seamlessly and timely with the national-driven movement and trend towards the preservation of location-based heritage and the promotion of Applied Learning program in schools. Central to this HCI program lies in its interdisciplinarity setting anchoring on the Knowledge Building Pedagogical Framework-- Idea Generation; Idea Improvement; Idea Synthetization and Idea Reflection—that promotes an authentic immersive experience for the student-participants while at the same time stimulates and elevates their level of epistemic agency and (inter)disciplinarity discourse which corresponds parallel with the principles and competencies expected of an active, informed and concerned citizen of tomorrow.

Classroom Design

The participants of this study were from one Secondary one (Grade 7) class. This class is considered the least academically inclined group within the stream. The teachers had observed that the class enjoys aesthetic-related activities but many are generally not inclined towards taking ownership in leading or spearheading events and happenings. Additionally, their sense of spatial awareness and affinity towards the Teck Whye community and national history is almost in the state of non-existence. Last but not least, a sizeable number of them had been ingrained with a fixed mindset due to circumstantial surrounding that resulted in low self-esteem and confidence. With these considerations in mind, the team carefully designed the HCI program that aims to address these concerns and in the process cultivate their love and deepen their commitment to the nation (refer to Table 1 for the detailed conceptualization of this program and Figure 1 for a diagrammatic representation of the process).

Table 1: Mapping the KB Processes and Interdisciplinarity KB Activities to the TWSS Citizenship Outcomes and the teachers' rationales behind the design

<table>
<tr><td>Program</td><td colspan="5">Heritage Curatorship and Immersion Program (HCI)</td></tr>
<tr><td>Citizenship Outcomes</td><td>Courageous Innovators (Concerned Citizen)</td><td colspan="2">Community Builders (Active Citizen)</td><td colspan="2">Critical Thinkers (Informed Citizen)</td></tr>
<tr><td>Citizenship Indicators</td><td>Inventive and Initiative</td><td colspan="2">Collaborative and Participative</td><td colspan="2">Reflective and Analytical</td></tr>
<tr><td>KB Principles</td><td>Real Ideas & Authentic Problems; Idea Diversity; Democratizing Knowledge</td><td colspan="4">Improvable Ideas; Epistemic Agency; Community Knowledge & Collective Responsibility; KB Discourse; Rise Above</td></tr>
<tr><td>KB Scaffolds</td><td>My Theory; Putting our Knowledge Together</td><td colspan="4">New Information; This theory does not explain; A Better Theory; Putting our Knowledge Together; I need to understand</td></tr>
<tr><td>KB Processes</td><td>Idea Generation</td><td>Idea Improvement</td><td colspan="2">Idea Synthesization</td><td>Idea Reflection</td></tr>
<tr><td colspan="6">KB Activities (Iteration 1): Building Citizenship Consciousness and Commitment through Heritage Orientation</td></tr>
<tr><td>Description</td><td>Students are required to share their views on heritage matters together with their perceived rationales of their involvement in this project before reading all the entries by their peers.</td><td colspan="4">As a group, they will then need to create an introductory paragraph that best consolidate and/or synthesize the varied information across the class entries before reflecting on the possible next moves with justification.</td></tr>
<tr><td>Rationales for this KB Activity</td><td>Increases the students' ownership and engagement towards the project</td><td colspan="4">(i)Nurtures a culture of collaborative and cooperative learning
(ii)Promotes meta-cognitive dispositions</td></tr>
<tr><td colspan="6">KB Activities (Iteration 2a): Building Citizenship Competencies through Historical Investigation</td></tr>
<tr><td>Description</td><td>After a short orientation tour around the vicinity, students are tasked to think of possible themes in the design of their group trail following with a detailed individual research on the Teck Whye region.</td><td colspan="4">Within the group, individuals will build-on each other entries with ideas and comments to strengthen their source analysis and inference. Next, the group proceeds to read, review and reflect on all class entries before conducting a face-to-face group dialogue to facilitate and negotiate towards a collective convergence and agreement of their group theme. Lastly, the students are given the opportunity to ponder and express their thoughts on the design and structure of the processes till far.</td></tr>
<tr><td>Rationales for this KB Activity</td><td>Creates an authentic history learning environment that emphasises on evidence-driven practice</td><td colspan="4">(i)Creates an authentic history learning environment emphasising on the constructive uses of authoritative sources and the importance of collective responsibility
(ii)Supports embedded assessment as learning through a culture of peer reasoning and referencing</td></tr>
<tr><td colspan="6">KB Activities (Iteration 2b): Building Citizenship Competencies through Music Composition</td></tr>
<tr><td>Description</td><td>With the familiarization of the technicalities behind music composition after undergo relevant training, each group needs to create a Teck Whye song and perform to the class.</td><td colspan="4">During the performance, other groups are tasked to listen intently and respond to the 3 given statements, ranging from lyrics construction to the dynamics of the enactment. Collectively, the performing groups will gather these feedbacks and take them into consideration for their next performance during the trail presentation (finale of the HCI).</td></tr>
</table>

Rationales for this KB Activity	Deepens the level of Historical Empathy through Contextual Appreciation	(i)Encourages the practice of active listening (ii)Helps students to understand that music involves collaboration and/or it is a social discourse and construct
KB Activities (Iteration 3) *: Building a Holistic Citizenship Experience through Trail Construction		
Description	Groups are required to conceptualize their 1st trail booklet incorporating at least 3 different disciplines (History, Music + 1 other) in alignment to a key Citizenship message/idea.	Through multiple rounds of refinement and enhancement (via online [KF with their peers and expert personnel] and offline [on actual on-site trial with their classmates and teachers]), the groups will proceed to generate their enhanced trail booklet that is ready to be issued to participants who will be joining their walking heritage tour during the school-based National Day Celebration.
Rationales for this KB Activity	Strengthens their meta-cognitive development	(i) Reinforces and underpins the power of community knowledge and advancement (ii)Showcases and celebrates the groups' growth and success

*Note: This activity is currently still in the implementation stage.

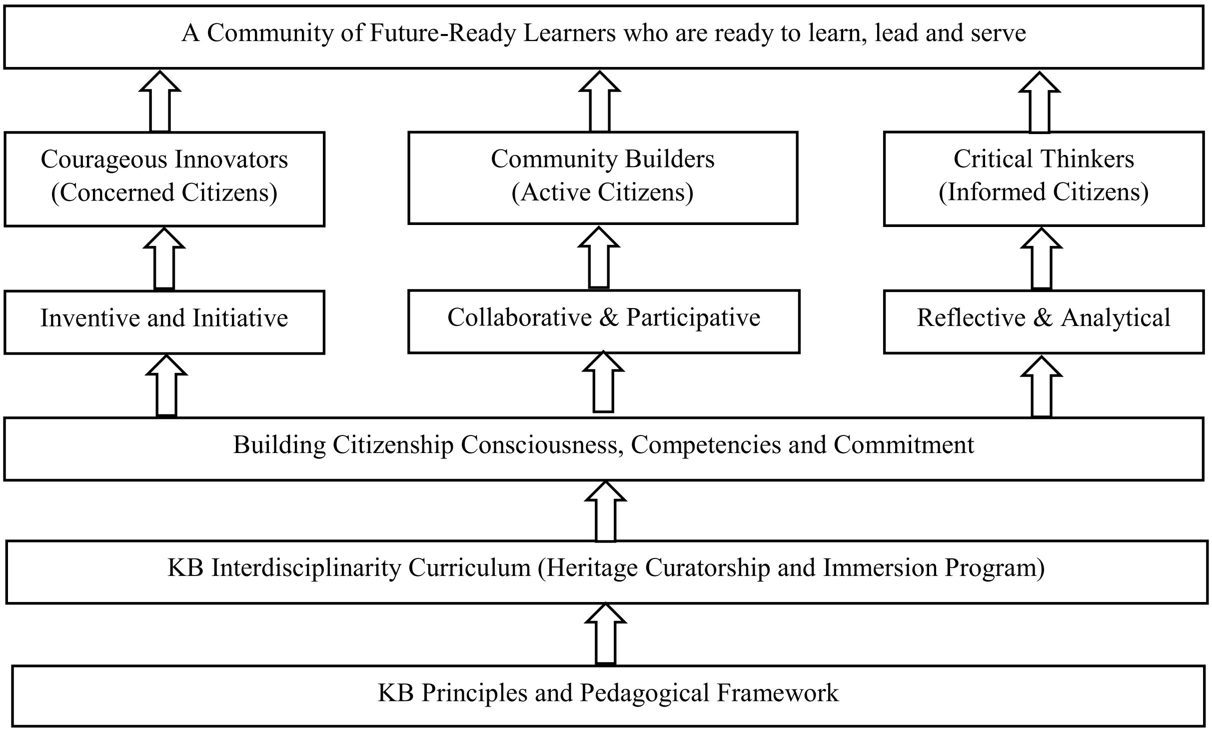

Figure 1: Diagrammatic Representation of the Process

Analysis of KB Activity Iteration 1 (Heritage Orientation)

Data collected includes students' notes, learning artefacts, reflection and Focus-Group Discussion, teachers' design document, observation and reflection. With the implementation of Iteration 1 that stresses on giving students the ownership over this heritage project within the context of a real and authentic communal setting, the team is heartened to notice the following that corresponds in alignment to the characteristics of a concerned citizen: (i) Groups are starting to take the *initiative* to explore the Teck Whye neighbourhood on their own such as conducting street interviews, having a conversation with the well-established shop-owners and to have a thorough walk-about around the region during the holidays (refer to Figure 2), (ii) Individuals and groups are beginning to express their heartfelt concerns *(empathy)* in preserving and conserving the memories of Teck Whye for the community, in particularly the elderly as reflected in their Knowledge Forum entries (refer to Figures 3 and 4) and (iii) all groups have either signed up for other Singapore-based heritage trails and/or downloading trail guides from National Heritage Board to broaden their understanding of heritage trails (ranging from its' conceptualization to operational matters) with the aims to apply these principles and ideas to the design of their Teck Whye Trail *(Inventive)* (refer to Figure 5).

After reading through the Knowledge Forum entries posted by all of you, our group concludes that we should not be keyboard warriors. Just like what some of you raises, our group think that this project wants us to be familiar with our surroundings and interact with the residents… this is a trail that is bigger than our project. It is a trail for the people…That is why we decide to go out and interview the residents and some old business-owners (initiative and inventive).

Figure 2: Extract from a group presentation to the class at the end of the Idea Generation segment

[Putting our Knowledge Together] Teck Whye: A place where some of our old generation of Singapore citizens lived their whole lives here. Time is running out! We should not keep the past buried in our old records and minds. These citizens need their stories to be told. Their lives in Teck Whye is still considered as a part of Singapore no matter how small their contribution is or how small Teck Whye is (empathy).

Figure 3: Extract taken from an introductory paragraph in a Knowledge Forum Entry (Group)

[My Theory]: I live here yet I do not know the history of this place. It is time for me and us to learn and be aware of Teck Whye in deeper context, especially how the elderly makes what Teck Whye is like today (empathy). Only then can we teach people about Teck Whye and hope that this will spread more with people becoming more interested in their own neighbourhood too and share the stories of their pioneers living in their neighbourhood, just like what we are doing now.

Figure 4: Extract taken from a Knowledge Forum Entry (Individual)

Our group downloaded the Toa Payoh trail and Balestier trail… The booklets are colourful and have some old pictures of the places. The places are arranged in a flow. They even have some quotes from the people who lived there last time. We think we should have these things in our trails…Maybe we can add in 1 or 2 other interesting ways too like let them have a 1 minute interview with people on the streets (Inventive).

Figure 5: Group sharing to the class during the reflection session (after the introductory paragraph)

The above analysis shows how the Knowledge Building processes and principles played a pivotal role in raising and nurturing the essential qualities expected of a concerned citizen: Inventive, Initiative and Empathy-driven. In addition, with the numerous quality Knowledge Forum entries (beyond 1000) being constructed in the next KB activities (Iteration 2a and 2b), the team is fully assured and strongly confident that having ownership arising from real ideas and authentic problems correlates to a higher degree of participation and commitment which are clear indicators of an active and informed citizen.

Analysis of KB Activities Iteration 2a and 2b (Historical Investigation and Music Composition)

After experiencing an inquiry cycle in heritage orientation that helps to nurture and develop an initial culture of collaborative and cooperative learning, students are now ready to embark on the next KB activities that aims to build their citizenship competencies as a critical thinker and community builder via the subsequent phase of the interdisciplinarity curriculum that involves historical investigation and music composition. Collectively, they strive to deepen the collaborative practices through a rigorous iteration with a strong emphasis on epistemic agency and disciplinarity discourse.

In the area of historical investigation, it has been observed that having an intensive building-on culture and reflective thinking process led to increasing number of students using the higher order KB scaffolds in both the construction of their personal thoughts and responses to the issues/comments given. Through these meta-cognitive developmental activities, it is evident that the class is pushing the frontiers of historical reasoning towards a more constructive use of authoritarian sources where students are no longer contented with just relevance but also the reliability of the sources (refer to Figure 6); towards complexity rather than dualism or simple causation and perspective of an event/idea as practiced by actual academics/historians (refer to Figure 7); and towards historiographical mode of thoughts—the defining moment of breakthrough in history training (refer to Figure 8). At this juncture, it is good to note that such above forms of historical reasoning are usually only seen in post-secondary educational landscape. Hence, it is without doubt that having this KB-principled activity is truly equipping and empowering the students towards advanced analytical skills and meta-cognitive dispositions that are essential (and way beyond their expected level) qualities expected of an informed and active citizen.

[New Information]: I think that my group initial research, findings and inference so far are pretty good. The sources are related to our theme. However, the area of concerns that I have noticed is that some of the sources are taken from either Wikipedia or online sites written by a person. Sources on the internet is already not 100% trustworthy. By taking information only from sites written by a person would add on to this problem [Reliability]. I think my group should stop taking information from Wikipedia…My friend suggested to do oral interviews. It is fine. But I have a thought that oral interviews might not be 100% trustworthy too. People might forget along time. People might remember only parts of it [Reliability].

Figure 6: Extract taken from a Knowledge Forum Entry

[Putting our Knowledge Together]: It is very hard to do research on Teck Whye. Some of the places have been demolished such as the train tracks as mentioned by A…Our main challenge is we have to search for information about Singapore transport to know why was the train tracks be removed and why was there train passing by here in the past…We learn that places are connected. To study history of a place means we need to study the history of other places and as what B suggests, probably even the HDB plans [Complexity involving multiple causations]…

Figure 7: Extract taken from group reflection during FGD

A: We should do on the changing faces of Teck Whye as suggested by a member from another group.
B: Great idea. So we focused on the buildings and transport?
C: Maybe we can consider how it changed in the short-term and in the long-term. I meant taking from the idea of an elderly who lives here for the past 50 years. Like in 1980s (short-term) and 2010s (long-term view) [Historiographical mode of thought: Intersection of Time and Context]
B: That is an interesting idea. I suggest maybe we can also look at the changing perceptions towards Teck Whye across the years? [Historiographical mode of thought: Intersection of Time and Forms of representation/Memories]
C: Hmmm… anyway to combine physical changes and the perceptions into 1? [Historiographical mode of thought: Intersection of subject disciplinarity]

Figure 8: Teachers' observation of a group during their group face-to-face conversation

Similarly, in the area of music composition, it has been observed that the KB pedagogical approach and interdisciplinarity curriculum is an effective enabler that gets the groups to begin thinking like a musician who understands and recognizes that a good and meaningful piece of music has to go beyond mere technicalities (refer to Figure 9) and are also gaining conceptual awareness and linkages between music and its broader implications/context (refer to Figures 10 and 11). With this deep and profound level of aptitude and thinking capacity arising from this KB disciplinarity discourse, the students are certainly demonstrating and reflecting the traits of a critical thinker who is analytical, reflective and participative.

[Putting Our Knowledge Together]: We think that the lesson is being structured this way because it helps us in our perspective. Music after heritage trail helps us to remember that the song needs to reflect the Teck Whye spirit. The trail helps us understand Teck Whye and its residents so it is really helpful to have this information when we compose the song… If we have started with music first, we would only write songs that we feel like it. It will not be what the Teck Whye is about… First-hand experience helps us for our songs. [Recognize that music composition needs to be connected with the unique features and/or experiences of places]

Figure 9: Extract taken from a group Knowledge Forum Entry

[My Theory]: Based on what we have done so far like research, read entries and reflect, I have just discovered that language, history and music are somehow linked together. Music needs words that reflects the emotions. History gives music the thing to write and helps us better understand the lyrics…Both history and music is an art that combines other things together… [Recognize the inter-connection and relationship between History, Music and Language]

Figure 10: Extract taken from an individual Knowledge Forum Entry

A: Song writing is like poster. We need to know what we want to say or sing.
B: Exactly. There is a purpose behind every song and poster.
A: Is this not what we learn in History too? Purpose?
B: Oh yes… Propaganda. Is song writing also a propaganda tool?
C: Maybe. But can be good propaganda. Remember what Mr Chan says. Posters can have good purpose such as fighting against diabetes.
B: Our Teck Whye Song is a good propaganda… We are doing something for the community.
A: Hope our song gives Teck Whye a good image to others.
[Recognize the function of music in relations to nation-building and social cause]

Figure 11: Teachers' observation of a group during their face-to-face song composition session

Data from the Knowledge Forum Learning Analytics further affirms and supports the tight causation and relationship between collaborative learning in a KB principle-based environment (indicator of a community-builder) with that of disciplinarity and meta-cognitive growth (indicator of a critical thinker) as seen in the table below (Table 2).

Table 2: Relationship between Vocabulary Density and Social Network Density

	Iteration 1	Iteration 2a	Iteration 2b	Remarks
Vocabulary Density (% of unique words)	8.6%	12.1%	17.9%	Indicators of Disciplinarity/ Meta-Cognitive Growth
Social Network Density (Words)	0.16/1	0.5/1	0.8/1	Indicators of the degree of connectedness
Social Network Density (Student)	0.032/1	0.06/1	0.05/1	

Beyond being inculcated with the necessary citizenship competencies that empowers the students to function effectively as responsible and informed citizens (critical thinkers and community builders) as seen in the above analysis of this iteration, the most fulfilling observation and authentic outcomes are the exhibition of these citizenship dispositions by the students' outside the scope and sphere of this HCI. During the implementation of the KB Iteration 2B, students from this class began to theorize and designed an integrated classroom environment that connects varied disciplines and subjects, ranging from having an Aesthetic Fitness Corner to Values-Driven Heritage Corridor to the curving of a Daily News Updates across geographical regions in the class whiteboard (a pioneering and innovative practice in the school's history). In addition, ideas of creating a Teck Whye Heritage

Newsletter have been conceptualized and put into place as part of the class initiative for the community. Citizenship consciousness, competencies and commitment has certainly been internalized, displayed and is now in full bloom as a result of a pervasive and rigorous knowledge building discourse experienced by the students.

Conclusion and Moving Ahead

My group would like to lead our juniors to capture more stories, memories and tales of Teck Whye. We can because we are able. We are the Teck Whye warriors!

Figure 12: A group sharing to the class during the implementation of KB Iteration 3

This above statement (refer to Figure 12) is a strong testimony to the study presented here where it shows how engaging in an interdisciplinarity knowledge building discourse via its 4 key processes can help secondary school students to develop a strong growth in the 3 key categories of Citizenship Education—Citizenship Consciousness, Citizenship Commitment and Citizenship Competencies. The analysis also suggests that with effective conceptualization and implementation, students are capable and genuinely interested in building and curating collective understanding and solutions to real and authentic problems. This paper proposes a comparative trail between 2 towns to heighten and intensify the meta-cognitive competency and national awareness of our students—who are the citizens of tomorrow.

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Towards the Realization of a Mobile Extended Knowledge Building Community

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Abstract: This article reports on an exploratory design experiment conducted over half a school year, with the goal of realizing a mobile extended Grade 6 knowledge building student community. By co-designing lessons, protocols and shifts in knowledge building practices, students were provided opportunities to capture discourse beyond what was immediately said in class. Additionally, they were introduced to the idea of anytime Knowledge Building and the power of contributing with multimedia to enhance their discourse. These changes allowed for a greater amount of in person discourse to be transferred online into a knowledge building community for further knowledge work to occur. This study highlights social, technological and practice based considerations that influence how readily students are able to contribute beyond formal learning settings and more effectively engage in Knowledge Building work to enhance the overall knowledge of their community.

Introduction

An overwhelming growth in the use of mobile devices for communications, collaboration and learning, highlights the tremendous reliance society has on digital technologies, particularly the ubiquitous ones in our pockets. Over the past few decades, Knowledge Building (KB) theory, practice and technology has been used as a catalyst to try and refocus education and student learning in preparation for twenty-first century work (Chen & Hong, 2016). The Organization for Economic and Cooperative Development (OECD), states that twenty-first century work is situated primarily around knowledge work and workers (1996, 2001). This has positioned KB theory well due to students gaining higher levels of agency in "the production and continual improvement of ideas of value to a community" (Scardamalia, 2003).

From a technology perspective, Knowledge Building has been supported by Knowledge Forum® as an online digital knowledge building community space for knowledge work to flourish. However, the current mode of learning, especially in an informal manner, has largely shifted away from stationary learning at a computer and become mobile. Mobile devices often become the first and most familiar device that students access for most of their personal digital needs. Despite mobile devices becoming habitually part of a student's daily life using it for concerted, sustained, and collaborative informal learning is challenging (Nouri et. al, 2001; Ryu & Parsons, 2012; Reychav & Wu, 2014).

As a result of a change in how students use devices and the need to prepare them for the future of work, there is a strong case for the extension of knowledge building theory to incorporate mobile learning. This article will highlight an exploratory study conducted at the Dr. Eric Jackman Institute for Child Studies (JICS) with the Grade 6 class. Specifically, it will outline the steps taken towards transforming the current practice of KB so that students are able to move towards the realization of a mobile extended knowledge building community, that supports pervasive knowledge building.

Background

"Knowledge Building as an educational approach is fundamentally an idea improvement challenge" (Bereiter & Scardamalia, 2014, p. 36). In order for ideas to be continuously worked and improved upon so that all may benefit, there needs to be motivated and engaged individuals who will take part in this work. Not only do these individuals have to be motivated and engaged they must have a collective responsibility for taking on the difficult task of creating new knowledge. There are three dimensions to collective responsibility, they include: awareness of the contributions of others, complementary contributions and distributed engagement amongst a community (Zhang et. al, 2009). When students are aware of other student's contributions they actively read through notes created by others in order to gain an understanding of the various threads of ideas that are being worked on. By understanding the landscape and overall direction of ideas, students are better able to provide complementary notes of their own. These additional notes will build on what was presented before, adhering to the fundamentals of KB. Lastly, the students are all required to be engaged in high-level decisions and directions of the overall community without any single person having overall authority. When a distribution of engagement is achieved all students gain a sense of responsibility for the direction ideas and the community are heading in.

While the personal demeanour of students in a KB community is important for collaborative idea improvement to occur successfully, the social structure of the classroom is also of great importance. The social structure can enhance or detract from how students work with each other, directly affecting their sense of agency. Chen and Hong state that in order for students to have a sense of collective responsibility for the knowledge they are working with and the direction of their own learning, groups need to form in an emergent and opportunistic manner (2016). As KB requires students to take responsibility in driving their learning there needs to be a social structure that is conducive for students to dive deeper into subjects, making meaningful connections between their experiences and ideas presented. The switch to KB further requires teachers to adjust their role so that they are better able to facilitate epistemological, cognitive and socio-cultural aspects of learning in order to hand students a high-level of agency. (Chen & Hong, 2016).

To conclude, knowledge building when applied to classrooms increases the agency of students, fostering greater collective responsibilities in iterative idea improvement of public knowledge. This increased responsibility leads to deeper learning both as a group and as individuals within a community that has a shared desire to use higher-order thinking to solve real problems. Despite the effectiveness of eliciting knowledge building behaviours or modes of thinking in students there is a missed opportunity to provide other channels for students to continue important knowledge work when they are out in the field. The affordances of smartphones allow for powerful contextual information to be brought into the community knowledge space. The inclusion of high fidelity multimedia further enhances how knowledge can be improved due to the additional dimensions these artifacts bring.

"Proliferation of smart mobile devices, such as smartphones and tablets, making them obvious choice of technology with which to engage students…they are now universal and mobile computers carried around by students, most of the time and impact in almost every aspect of their lives" (Cheong et. al, 2012, p. 98). Overall, mobile devices can be used to support collaborative learning as they are effective at engaging individuals, and enhancing communication in general. Students actively use them in their daily lives for a plethora of reasons not limited to only voice or text based communication. The resulting technology ecosystem in society is one filled with ubiquitous devices connected to ubiquitous networks that offers the flexibility and mobility for students to continue learning even when not in a traditional learning environment (Mwanza-Simwami, 2016). With the continuous improvement of technology and rapid adoption by each generation of students it becomes necessary for educators to engaged students through the same devices students are already familiar with (Cheong et. al, 2012). This allows for faster adoption and decreases frustration on not being able to use the technology (Echeverria et. al, 2011; Cheong et. al, 2012).

The adoption of mobile devices to use in collaborative learning is natural for students as they "enjoy the connectivity and social interaction which occur from the use of these devices and prefer group-based activities" (Cheong et. al, 2012, 98). As students are more open to group activities, introducing a mobile extension to knowledge building will be beneficial as there is low risk students will not use it, particularly if it offers the flexibility they are used to when accessing and creating new knowledge. Responsive sites built with mobile in mind also allow multiple channel access to Knowledge Building Communities such as through desktops, laptops, and smartphones, again fitting with the existing means students use their devices (Cheong et. al, 2012). Lastly mobile devices allow for knowledge building to occur anytime, anywhere, reifying knowledge through various visual, textual and audio metaphors (Baloian & Zurita, 2012; Caballé et. al, 2010).

In summary, multichannel and multimedia knowledge creation allows for ideas to be continuously improved upon in a time sensitive manner with contextually rich notes. Fostering the necessary high-order skills in problem-solving, idea improvement, knowledge building amongst others, which are paramount for students to learn in order to be successful in our current knowledge focused society.

Methodology

A design based research (DBR) methodology was used in this exploratory study of how mobile devices could broaden the reach of an active Knowledge Building Community (KBC). The context-sensitive, collaborative and iterative characteristics of DBR (Wang & Hannafin, 2005) are well suited to the development of solutions that improve educational practices in a unique environment such as JICS. In the context of this study, interventions will be conducted to affect gradual changes in how students build knowledge together so they are more comfortable with the notion and practice of pervasive learning. Similarly exploring, experimenting and interacting on an authentic problem within a specific context aids teachers in utilizing theory, practice and technology in a more effective manner that not only resolves the issue but further enhances student learning (McKenney & Reeves, 2013).

Collaboration is another key element that needs to be considered when exploring design solutions, especially when trying to aid students and teachers realize the potential of mobile learning. As researchers without in-depth prior knowledge of the specifics regarding a classrooms operation, social dynamics, teaching practice and student learning habits, it is paramount to work closely with the teacher and JICS students to develop appropriate practices of anytime KB. Through a close partnership between students, the teacher and researchers DBR hopes to affect real sustained change in how students build knowledge, especially in thinking more creatively about mediums of expression, times of contribution, and criss-crossing idea landscapes (Scardamalia, & Bereiter, 2016).

As DBR is grounded in theory such as Knowledge Building in this case, it can be used as a framework to systematically conduct research and to iterate upon and develop new theories or practices (Wang & Hannafin, 2005). One of the key strengths of DBR when applied to a unique problem such as mobile extending knowledge building is the iterative and flexible cycle of development (DBRC, 2003). By starting out with KB theory as a basis for understanding the goals students are reaching for, one can successfully iterate on practices in the classroom that moves everyone closer to the realization of mobile knowledge building. Specifically, through interventions the research team and teachers are able to develop an informed understanding of the problem they need to solve. Through regular meetings and adjustments to practice and technology students gain increasingly amounts of epistemological agency in their learning whilst developing necessary skills in global competencies. Through iterative interventions the end design solution quickly moved from a technical solution in the form of mobile application to a practice-based solution that involved consistent and rapid application of knowledge as a means to enable further student growth in the use of KB theory in their everyday lives.

Research Context

The entire Grade 6 class of twenty-three students (*n=23)* participated in the design experiment to explore how students could use mobile devices in capturing their discourse. This class was selected due to having a history with using Knowledge Forum® (KF) as well as having mature experience implementing KB socially in class throughout their time at JICS. In addition, the teacher had a specific interesting in how mobile devices could be used to benefit teaching and learning whilst simultaneously reducing barriers of time and space.

News was the main topic in which KB theory was embedded and actively used in. This segment of the class sought to enable students the greatest level of agency in determining what they would discuss as a community. Specifically, students would present their particular item of discussion and seek to engage others with thought provoking questions. Subsequently, peers would determine ways of getting deeper into the topic, collaboratively expanding the community's knowledge by building-on, and rising above. Students were able to apply KB theory in a free-flowing manner that allowed them to pair theory with discourse on topics of interest. Furthermore, *News* aided students in learning about the application of KB theory so it could become habitual behaviour that can be readily applied in everyday life to a variety of topics. This is an important step in preparing students as it instills a KB mindset. With the proper mindset and regular use of KB in everyday discourse students can begin to apply KB in manners that are technologically agnostic. Ultimately students are better prepared to adapt KB to a variety of environments, whether they are in person, on a computer or through a mobile device.

Findings

After observing the class on three separate occasions a few trends emerged. Firstly, the *News* sessions are highly structured in their approach. There are three main roles: presenters, commenters and facilitators, each playing an important role in how *News* time functions. Presenters summarize their news article and ask open-ended questions to the class, then pick a student to answer. Subsequently, students that answer choose the next student to answer, which the class calls *passing-on*. Each student that speaks does not get to speak again during the rest of the *News* time in order to give everyone a chance to participate. Despite this rule, students are very enthusiastic about answering questions and often go on tangents if the topic is of particular interest to them.

In this manner, KB is occurring at a cursory level without many of the conversations going deeper until the facilitator, which is either the teacher or assistant teacher synthesizes the discussion and asks a deeper follow-up question. When this occurs, students refocus again and begin working on the new prompt, but it does not always guarantee deeper or even meaningful knowledge work. Lastly, the flow of discourse towards deeper meaning is stalls when one person finishes talking and needs to pick another student to continue. Although these issues may be a result of the way KB *News* is structured it highlights areas in which technology can negate some of the negatives of face-to-face KB discourse so that more of the conversation is captured, archived and workable.

The purpose of the interventions is two-fold: one to break the current method in which KB is occurring, so that students are more accustomed to using KB theory in a pervasive manner that is not tied technology, place or time. The second objective is to teach students the value of contributing through multiple mediums. Different mediums offer students the ability express their thoughts in manners that has potential to engage others in a variety of ways, leading to richer discourse (artifacts?). Furthermore, these interventions sought to empower students so they may discover various methods of capturing their everyday discourse and continue working on it without geographic and temporal restrictions. Moving from face-to-face to online KB without losing focus on what has been worked on, and what requires further attention. As a result, interventions sought to improve KB application mindset and the possibilities of multimedia expressions, in preparation for a society that is ever-reliant on mobile devices.

Intervention One: Anytime KB

The first intervention introduced the class to the idea of anytime KB, where students are free to contribute their thoughts to KF at any given time, so that they could start shifting their perceptions of KB and its association with a specific period of time where they use KF. Students were encouraged to always be thinking about working with ideas, or building on the knowledge of others, regardless of time or location. Student's welcomed this shift in thinking about KB as they often had thoughts about *News,* worthy ideas, and build-on's at all times of the day. However, previous to this intervention the practice of KB was segmented around a particular time of day, like in *News*, resulting in many ideas being lost without making an impact or being included in the overall knowledge fabric that is created in class. As for actual contributions after being invited to freely access KF, there was large initial contribution (*n=15)*, during the first day of the intervention, subsequently contributions dropped sharply as the week went on (*n=3, n=5, n=5).* The lack of contributions beyond the regularly scheduled *News* time highlights the discrepancy between how students feel about contributing whenever they have a thought and when the contributions actually occur. Students are disengaged with the notion of deeper knowledge work or at least anytime contribution when they are not in the class. Reasons for this behaviour requires further study, but initial thoughts and observations indicate that students need to have a reason to contribute and perhaps more importantly, a community that will interact with their contributions.

Intervention Two: Multimodal Expressions

Even though anytime KB was embraced by students it would still take time for pervasive learning to occur naturally. To further assist in the transition away from static learning, multimedia expression of ideas in KF was demonstrated to the class. The goal was to engage students in the production of knowledge artifacts that allowed greater epistemic agency and creativity. Both of which could result in a richer landscape of ideas that the community could work on to constantly improve week-over-week.

A custom KF page (see Appendix 1) was built as a vehicle to highlight how different forms of expression could enable greater range of knowledge artifact production with the aim of transferring agency to the students so they take responsibility in how knowledge is built within their community. Students were asked to transform and explore the creation of multimedia artifacts that built-on previous text-based ideas. In this manner students could further build on the notion of anytime KB through audio, visual, or textual metaphors.

In addition to showcasing KF, the class was asked which features presented were the most interesting to them (see Table 1).

Table 1: Student Interest in KF Features

Feature	Approximate Interest (%)
Linking	30%
Embedding Videos	30%
Rise Aboves	15%
Images/banners/visual labels	50%
Accessing KF on Mobile (smartphones, tablets etc.)	85%
Audio Notes	85%

Although students focused on technical aspects of KF, they are good indicators of the level of agency desired by students, as well as the means in which they access information in their everyday lives. For example, many of the students already use their parent's mobile devices to create, communicate and consume. Their affinity towards audio notes or the ability to create audio artifacts, also suggests multimedia in an audio and visual format is something they are more use to, rather than only text. Beyond a better user experience on a KB platform such as KF, multimedia artifacts are deep in meaning, providing a wider range of knowledge that others can use to actively build upon. It also serves to promote pervasive learning as the possibility of anytime KB from a mobile devices is inherently multimodal. Images, video, audio and text are regularly combined in daily student life, in situ, to share knowledge.

Intervention Three: Concurrent Capture

Following the second intervention, engagement remained low, which could have been a result of end-of-year activities at JICS or a lack of perceived community importance towards building knowledge pervasively and with multimedia. In an effort to increase engagement and further seek changes in habitual KB practices, concurrent capturing of authentic real-world discussions during *News* was introduced. The aim was to create a sense of a community through the active participation of all students, whether they are speaking face-to-face or contributing ideas online. As their KF space was projected in the classroom, it provided those that were entering notes online to also have an audience. The second aim of concurrent capture was to see how much of a face-to-face KB session could be recorded online as artifacts for further build-ons and knowledge work to occur. There were many cases in early observations where knowledge work that occurred in person was not recorded, resulting in KB not occurring as information is not archived for further use.

With all students having access to their laptops while participating in *News*, ideas were observed to flow much quicker from face-to-face sharing to online notes. Presenters were asked to post their articles and questions online and commenters can actively reply when they have a thought whether face-to-face or online. This intervention saw the number of notes and build-ons increase, averaging four new notes and four build-ons each day for one school week, totaling twenty-one new posts and build-ons. The additional method of contribution seemed to engage more students in the class, as the issues associated with *News* were mitigated with another avenue of idea production. It would worthwhile to study the percentage of in person KB was captured online, and how deep concurrent KB goes in comparison to strictly online KB.

Lastly, the teacher stated that it would be interesting to note what information arrives on KF in comparison to what is discussed in person, as KF to him, is considered a repository for the overflow of information that cannot be discussed during class time. The teacher once again pointed to the idea that social feedback is crucial in the success of KF as a KB tool, as students can see actual progress when they are posting live in comparison to when they are posting on their own. This presents another avenue of inquiry as a KB mindset should and is much greater than a tool that enables it, so it would be valuable to see how effective KB would be with multiple mediums and tools.

Intervention Four: Audio Contributions

The final intervention focused on introducing students to contributing ideas through audio, something they have been asking for since beginning of the study. Audio artifacts allow for another form of expression by students, further expanding their level of epistemic agency with another tool for idea production. The richness of audio artifacts can further enrich KB in that it has the potential to provide depth of information, written word and text does not. For example, tone and emotion, which are important nonverbal cues, can change the way information is perceived by others. Building on the notion of concurrent capturing of ideas and pervasive learning, part of mitigating asynchronous communication issues that often occurs in online environment is offering mediums of expression that are closer to face-to-face discussions.

Despite the value of audio contributions, they were deemed too complicated for students to actively use without greater instructional assistance by the teacher. As a result, the researchers would demonstrate how audio capture occurs and provide students with a workshop of the audio recording process and invite them to try it in the future. Students would continue capturing their discourse as in the same manner as the previous week but have audio recordings of the entire discourse included for them to listen to, reflect on, and make use of.

Conclusion

The exploration of how a Grade 6 class uses Knowledge Building theory and the companion platform of Knowledge Forum® has revealed many areas that require further study. Despite having years of exposure to KB and KF it was found that technological barriers had a dramatic impact on how the class thought about the theory and platform. In order to re-envision KF specifically as a vehicle for deeper and more meaningful discourse, social and practice based changes were required to shift the focus on capturing and exploring of knowledge. To accomplish this task, and to move towards mobile extension of KBCs there were several problems that needed to be resolved: attitude towards the platform, actively supporting class through demonstrations that closed gap between knowledge and action, co-designing solutions with the class to empower them with greater agency.

To truly help a class move towards pervasive learning that is rich in context and multimedia one needs to first build up a level of confidence in the system being used. Assuming that repeated exposure to KB or KF equates to proficiency can be detrimental to the success of the students when they try to apply the theory to their own learning. Furthermore, this study highlights the need to include more of the classes feedback into how KF is being used so that they are part of the solution. Through iterative changes to attitude and practice one can foresee the students develop a deeper understanding of the theory and its applications. Mobile technology, although not fully explored in this study requires more than the implementation of the technology but rather a steady shift in how to think about contributing of ideas so that the community can benefit from more diverse perspectives and delve deeper into ideas of worth.

Although, technical changes can be seen as a rapid method of increasing user experience of the KF platform and moving it more in line with how students use devices informally, the true challenge lies in changing practice and mindset surrounding KB in students and teachers. As seen in this study, even without technology KB can and does occur, and the resulting discourse is both rich and deep. The detriment to face-to-face only KB discourse is the lack of artifacts produced. Artifacts are necessary as a means of reifying ideas in a physical or digital format that can be further developed, connected and ultimately absorbed into the larger knowledge consciousness of a community. This study has further shown that in order for students to accept KB as a part of their toolset for learning, it has to fit within their social understanding of their community. That is, KB without community of peers that respond and work together is a very lonely endeavour. Despite the necessity of technology improvements, they should be thought of as vehicles for enabling more efficient, engaging, and deeper levels of KB rather than the ultimate solution.

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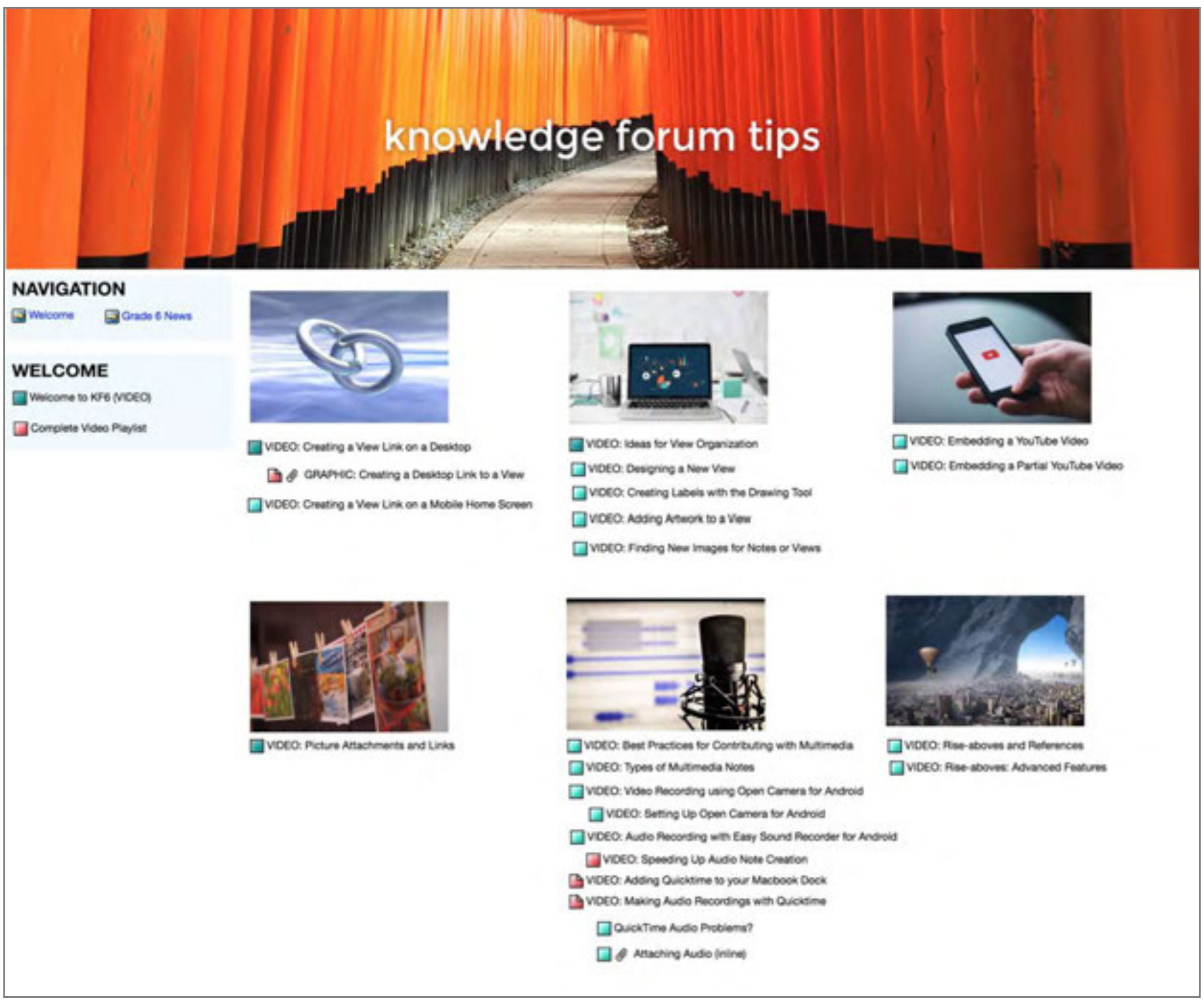
Appendix

Appendix 1: Knowledge Forum Tips



Building on Design Thinking: pedagogical challenges and *Titanic* solutions

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Abstract: This paper charts our efforts aimed at developing students', (novice designers), creativity, complex problem solving skills and innovative potential through combining design thinking and knowledge building. Over three case studies, we went from evaluating design thinking as a creative problem-solving tool to combining the process and practices of design thinking with the principles of knowledge building. We find that this enables students to work creatively with knowledge and helps sustain idea improvement. With these case studies as the background, we explored how to communicate design thinking and knowledge building to students as this faces some pedagogical challenges. To facilitate this process we used the sinking of RMS *Titanic* in 1912. Faced with the problem, "How could more lives have been saved?" using a design thinking methodology saves over 700 additional lives, teams using the combined approach develop solutions that *may* save the entire ship. The challenge enabled students to engage in sustained collaborative idea improvement and gain an introduction to the concepts of design thinking and knowledge building.

Keywords: Knowledge building, design thinking, creativity

Introduction

In our experience, students and novice designers who lack domain experience or procedural knowledge benefit considerably from a process. Design thinking is a creative problem-solving process including several practices aimed at ensuring ideas are generated freely, expressed visually, combined, prototyped and tested. It uses a process map in five steps: understanding user needs, framing problems to understand real needs, generating ideas, prototyping solutions and obtaining feedback. Some of the criticism directed at design thinking has implications for teaching it and for using its potential as a driver of innovation. A widely acknowledged issue in the design thinking discourse is the difficulty explaining what design thinking is, there is no generally agreed definition and the "literature on which it is based is contradictory, (Koh, 2015). Rylander, (2009) suggests that it is "hard enough understanding design and thinking, let alone design thinking". Knowledge building also has some challenges when it comes to communicating the concept to students. While it has an agreed definition as a social activity focused on the continuous generation and improvement of ideas, (Scardamalia & Bereiter, 2006), it is based on a set of principles rather than a process or prescribed methodology. These principles, aimed at maintaining creative, sustained idea improvement for example "epistemic agency", "scaffolding" and "rise above" require explanation. Scardamalia & Bereiter, (2006) acknowledge that adhering to a principled rather than a procedural approach has undoubtedly impeded the spread of knowledge building. A second issue is the type of innovation that might be expected from the human-centered design-thinking approach and the role of empathy as a starting point for radical innovation. Human-centered design has attracted some criticism for lacking the skills & knowledge required to generate radical innovation, (Norman & Verganti, 2012). Knowledge building has as its starting point a critique of the status-quo and use of expert sources of information.

According to Nonaka & Takeuchi, (1995), the key to innovation is knowledge and most problems require both creativity and knowledge to solve them, (Dörner & Funke, (2017). We were interested in exploring how design thinking would assist novice designers cope with these types of problems. While students are generally able to generate ideas, remaining actively engaged in continuous idea improvement is not something that comes naturally to most students, (novice designers), (Scardamalia & Bereiter, 2006), but the principles and building cycle of knowledge building might help make explicit what some highly effective teams do implicitly when engaged in problem finding and innovative concept development.

Background, three case studies

For some time, we have been experimenting with using a design thinking methodology to assist multi-disciplinary student teams generate innovative solutions to ill-defined, ambiguous (wicked) design problems, (Rittel & Webber, 1973). Our experience has been that when students are confronted with such problems and encouraged to develop solutions using a design thinking methodology, innovative solutions are often generated, whether in the form of artifacts, processes or systems, (McElheron, 2017). In an attempt to explore this further and isolate the effects of design thinking, our approach has been to run studies where the innovative concepts from teams of students using design thinking are compared with the concepts from teams of students who do not. Following this, we further experimented with adding knowledge building to the design thinking process in order to understand how this extra focus on knowledge would affect the students' suggestions for solutions. In the following, we will briefly describe three cases studies that investigated the effects of design thinking and/or knowledge building: the three case studies serve as a background for the main study in the paper: The *Titanic* problem.

Case study one: Design thinking with a well-defined problem

A cohort of 72 BA fashion design & business students in their 2nd semester was divided into 20 teams, and presented with a product design challenge - to develop an urban bicycle concept. All teams were provided with a design brief specifying the requirements of the design, (new generation of urban bike, quality of design, flexibility, integration of features, aesthetics, mandatory features etc.). Half the teams were asked to use the process and practices of design thinking. Half the teams did not use design thinking.

The teams' concepts were evaluated by a panel of experts using the Taxonomy of Creative Design, (Nilsson, 2012). The concepts from the design thinking teams scored significantly higher on the taxonomy in terms of the variation, combination and transformation of ideas. Our observations suggested that the teams not using the design thinking process jumped directly to solution mode, ideas were generated, but often not captured or developed. These teams tended to fragment early working on separate tasks and communication between team members suffered. Conversely, the teams using the design thinking process and practices spent more time framing the design problem, generating ideas and considering technical feasibility, desirable & viability.

Case study two: Problems that require both creativity and knowledge to solve them

In looking for a longer design period than a short workshop, two teams of six BA Business and Engineering students in their 5th semester, were observed over five days while engaged in solving an ambiguous problem using the same design thinking methodology used in case study one. The design challenge was to design an app that would enable people with ADHD/Autism (AUT) to monitor their emotions and get feedback on them seeking to reduce anxiety in their daily lives. To work with this challenge, the teams would have to acquire substantial knowledge of the ADHD/AUT condition, and what this means in terms of problems with self-direction, executive function, social interaction and communication.

Both teams succeeded in developing and presenting solutions that the sponsoring company considered innovative, feasible in terms of functionality, and cost. However, one team concept was far more sophisticated and as a team they differed from the other team in several important respects. Firstly, they demonstrated a high level of knowledge about the subject, specifically a deep understanding of the ADHD – Autism – Anxiety cycle that is typical for people diagnosed with this condition and how this might be disrupted. Secondly, how this knowledge made its way into the team's concept and thirdly in the way they acquired this knowledge.

Where the one team followed the same design thinking process and practices in case study one, the more successful team followed a different pattern when on day two they started to be engaged in what Engle & Conant (2002:44) describe as *research – share – perform* cycles, where students "collaboratively construct meaning and action thereby transforming the classroom into a community of discourse". Their focus was on acquiring knowledge as a community – not just as individuals. The team frequently created concepts, ideas or theories which were used to acquire further knowledge. Effective use was made of "expert" sources of information, including people with ADHD/AUT and their carers. They continued to reflect on what they knew, and what action or knowledge they needed to move forward. Their concept emerged gradually over the five days: as they knew more, they could begin to develop solutions that addressed particular problems that they had identified through their new found knowledge.

The way this team operated reflected several features associated with the principles of knowledge building proposed by Scardamalia & Bereiter, (2006), which is concerned with the sustained collective generation and improvement of ideas.

Case study three: Building on design thinking

The observations made in case study two caused us to ponder how an increased focus on the principles and techniques of knowledge building could be combined with the processes & practices of design thinking. In order to explore this question further we ran a study involving 100 BA Business and Design students in their 2nd semester that we divided into 20 teams and presented with a challenge related to sustainability - to develop a set of ideas that would help a western European family reduce the environmental footprint from domestic laundry. We asked them to produce ideas of two types. Firstly, what we called "hygiene" factors, things that could be implemented relatively easily with existing technology and would fit in with current life-styles & behavior. Secondly, we asked students to suggest more innovative ideas that may need to combine technologies from other areas or require significant changes in behavior and lifestyle. Students were asked to document how their ideas would reduce energy, CO_2 emissions, water savings, chemicals used etc.

Half the teams were asked to use a design thinking methodology and half were asked to combine this with knowledge building principles, (Scardamalia & Bereiter, 2006).Theoretically, there is a potential relationship between knowledge building and design thinking. Both adopt a constructivist approach to learning, in the case of knowledge building, deeply constructivist, (Bereiter & Scardamalia, 2003). Both address real-world problems and focus on working creatively with ideas. Regarding their differences, knowledge building is more concerned with the advancement of knowledge as a learning outcome whereas design thinking often requires the production of a product or artifact, (Koh, 2015). Design thinking takes understanding user needs as its starting point and knowledge building starts out with a critique of the status-quo and makes use of expert sources of information. This meant that we made several modifications to our model of design thinking, these are the shaded areas in figure 1.

Figure 1: The design thinking model modified to incorporate the principles of knowledge building (shaded).

For the design thinking / knowledge building teams, in addition to user empathy, the starting point, (FIND), included a critique of current laundry practices and a search for expert knowledge. This knowledge was shared prior to problem framing. Ideas were generated and the most promising ideas prototyped. In keeping with knowledge building principles, prototypes could take the form of "epistemic artifacts", opinions, theories, questions. Teams were encouraged to use a knowledge building cycle, a major addition to the design thinking model where teams take the opportunity to reflect on what they know so far, their most promising ideas, what they need to know in order to develop their ideas further and an action plan to close the knowledge gap.

For this case study, all team concepts were evaluated using fluency (number of ideas), flexibility, (types of ideas), originality, (idea novelty) and elaboration (level of detail), (Guilford, 1988), plus an additional factor: R.V.E., (relevance and effectiveness). Evaluators gave one score for the "hygiene" factors and one score for the innovative concept. The design thinking / knowledge building teams received the highest score for the hygiene factors which contained significantly more elaboration, indicating a higher knowledge content. While the number of innovative ideas was similar from both sets of teams, the teams using knowledge building scored significantly higher across all measures but especially in terms of the level of elaboration again indicating a higher knowledge content of the concepts.

The process followed by the design thinking / knowledge building teams was supported by knowledge building principles: use of expert sources, take collective responsibility, strength in diversity, working creatively with knowledge, continuous idea improvement, rise-above, (Scardamalia & Bereiter, 2006). Observations made on both sets of teams indicated the design thinking / knowledge building teams developed their concepts later in the workshop relative to the design thinking teams. In terms of encouraging teams to remain actively engaged in continuous idea improvement the inclusion of knowledge building principles and the knowledge building cycle appeared to help.

Using design and knowledge to solve *Titanic* problems

Based on the experiences in the case studies, we wanted to make a further study that both explored what differences knowledge building makes and that addressed the pedagogical challenge mentioned in the introduction. Specifically, the challenge of communicating two ambiguous concepts to students meeting them for the first time and how the value knowledge building brings to design thinking can be demonstrated in a meaningful way. Understanding does emerge over time but we were looking for ways to facilitate the process. Wicked problems abound in design thinking and we were in the search for a challenge which was well structured, had a sufficient level of complexity and be a stimulus for authentic activity (Duffy & Cunningham, 1996). Also one that allowed for multiple solutions with several layers of complexity and innovation. We chose a titanic problem, specifically, the sinking of RMS *Titanic* in 1912 resulting in the death of over 1500 passengers and crew, only just over 700 survived. Could more lives have been saved?

Methodology

Students with no prior knowledge of design thinking or knowledge building were placed in multi-disciplinary teams and informed that the problem they would be solving was: "following the RMS *Titanic's* collision with the iceberg, how could more passengers and crew have been saved?" The teams were given a briefing consisting of a list of facts & figures known to the crew of the *Titanic* at the time. It became quickly obvious to the Captain and chief officers that the ship would sink in under two hours, (it actually sank two hours 40 minutes following the collision). 2,227 passengers and crew were on board and 20 lifeboats were available, each with a maximum capacity of 65, enough for only 53% of the passengers and crew.

Teams were provided with information about the scene of the collision. It was a clear night and the sea was flat calm. A ship, the SS *Californian* had been sighted approximately 6 miles in the distance but is not responding to the *Titanic's* distress signals. The iceberg is less that one mile away. The teams were then instructed to construct a "mock-up" of the scene approximately to scale using materials made available. Teams were further informed that the passengers were initially calm following the collision and reluctant to get towards lifeboats feeling safer with the ship and its captain. The *Titanic* had a reputation of being unsinkable, (though the owners, the White Star Line never made this claim), and had several safety features. All teams were then taken through the college's design thinking process model and practices which consists of five phases: a research stage followed by problem framing, idea generation, prototyping and concept testing.

The teams were invited to frame the problem of passenger survival and to generate solutions and prototype their most promising ideas. The challenge was run in two phases. **Phase one** was the design-thinking round where the teams were instructed to generate solutions using the design thinking process and practices. A facilitator was available to provide assistance but not to provide or evaluate solutions. A time clock showing ship's time was projected onto a screen starting at 11:40 when the *Titanic* struck the iceberg and displaying information as it became available to the crew in real time. This included: at 12:25 a rescue ship, RMS *Carpathia* sails towards the *Titanic,* estimated time of arrival – four hours. After 60 minutes, the teams are asked to present their ideas to the facilitator and estimate how many lives their concepts might have saved, typical results from this stage of the challenge can be seen in Table 1.

In **phase two** of the challenge, students were introduced to the principles of knowledge building and scaffolding. The principles are aimed at keeping the focus on the continual improvement of ideas. Scaffolding in this challenge took the form of questions and statements that help bridge the gap between problem and solution. Teams were then taken back to the start of the unified model. They were asked to carry out a critical analysis of the events following *Titanic's* collision with the iceberg, then frame a series of questions to be put to an expert, in this case the facilitator who had read into the events surrounding the sinking of the *Titanic* in some detail. A further round of idea development followed and after a further 60 minutes, teams prototyped their best solutions and estimated how many passengers and crew they were likely to save. Typical results can be seen in Table 1.

Observations and results

During phase one, (the design thinking phase), teams tended to frame the problem in a similar way: "How do we save as many passengers as possible?" They reason that people being reluctant to get into lifeboats might be due to a lack of information?

In phase two of the challenge where knowledge building principles were introduced, the teams generated a list of questions which challenged the status quo of events following the collision, for example: "Why didn't 53% of passengers make it into the lifeboats?" and "Were all lifeboats launched and how full were they?". These are obvious questions and the facilitator was prepared for them. Only 18 out of 20 lifeboats were launched. The consensus in the literature is that there was a general reluctance to abandon the ship and the captain's order "women and children first" was interpreted as "women & children only". As a consequence, several lifeboats were launched with plenty of room for more passengers, simply because there were no more women & children in the immediate vicinity, (Greely, n.d,).

The teams were encouraged to further critique the status-quo and this generated additional questions: "How sure are we that the skip is sinking, isn't it supposed to be unsinkable?" "If the ship is sinking, could anything be done to prevent this or at least slow the process down?" "How big is the hole in the hull?" "Can holes be plugged in some way"? The "expert" was able to offer answers to these questions. Teams using knowledge building often ask if any photographs of the lifeboats or the iceberg are available. There are, (see figures 2 and 3).

Figure 2: Photograph taken by a passenger on the *Carpathia* of the last life boat to be rescued. Courtesy: WikiMedia.

Figure 3: The iceberg struck by the *Titanic*, photograph taken by the chief steward of the Prinz Albert. Courtesy WikiMedia.

This raised the comment that the iceberg looks a lot flatter than they had imagined and in this study generated the question, "Would it be possible to put passengers on the iceberg?" The expert could confirm that people have survived shipwrecks by climbing onto ice floes and invited teams to think of ways in which they could establish the feasibility of this idea. Upon seeing the photograph of the lifeboat, one student commented, "Why are people wearing life vests, they don't need them, they take up a lot of space and could be used to build more rafts?"

Teams were encouraged to use the knowledge building cycle to reflect on their progress and take action to close any gaps in their knowledge. The action plan was often, "consult the expert". Most teams reframed the problem to how to delay the sinking of the *Titanic* and keep passengers out of the water *for three hours*. This reframe with the shorter time-frame had the effect of adding feasibility, in the team's eyes, to several of their solutions. The teams most promising ideas and estimates of the number of passengers and crew their suggestions might save can be seen in table 1.

Table 1: Student team ideas and estimates of lives saved

Phase one: Design thinking solutions	Phase two: Design thinking and Knowledge Building
Address the unfilled lifeboat situation, (communicate & keep people calm) Use floatable materials to make rafts Attempt to contact the *Californian*	Damage control: block holes in the hull, seal off compartments, allow the ship to flood evenly. Further develop floatation devices: Use more effective materials, drums, car tires etc. Create catamaran type structures. Construct survival suits. Sail the ship towards the *Californian.* Iceberg: put people on the iceberg, anchor the ship to the iceberg. Crew allocation: damage control, raft construction, supervising lifeboats.
Typically 3 ideas, lives saved, approx. 1225 (55%)	Typically 5-7 ideas, lives saved, 2000-2200 (90-99%)

Discussion

All teams managed to save significantly more passengers than the 705 (33%) that actually survived the sinking of the *Titanic*. However, the teams were working with hindsight and near perfect information. Their "passengers" were compliant model figures rather than real passengers in an increasing state of distress and panic and with crew having to cope with a deteriorating situation. Their solutions only had to be prototyped rather than implemented in real life.

When evaluating the team's suggestions, we consulted the extensive literature available concerning how more passengers on the *Titanic* might have been saved and consists of numerous websites, journal articles, blogs, books, videos, documentaries etc.

All teams addressed the unfilled lifeboat issue highlighted in the brief and the team's solutions, had they been implemented, would have saved more lives. Constructing improvised rafts, making greater effort to contact the *Californian*, and plugging the holes in the hull are ideas that might have saved lives or delayed the sinking of the ship. Placing people on the iceberg is arguably the most controversial suggestion. It is a much-debated topic and opinion is divided about the practicalities however, there have been many documented cases of passengers surviving shipwrecks by climbing onto ice. The team's suggestion to discover if this was possible was to send a lifeboat with crew equipped with lights, ropes, ladders, spikes etc. to assess the situation. Not all suggestions made by teams would be effective, the literature suggests that balancing the flooding of the ship would not have delayed sinking and anchoring the ship to the iceberg would have involved considerable risk.

In interviews with team members post-challenge, the general opinion was that the design-thinking process and practices were helpful in solving this challenge. Concerning the introduction of knowledge building, most students felt that critiquing the status quo and "consulting the expert" were highly valued and that this helps teams validate or reject trains of thought. The principles of knowledge building are relatively easy to understand and the knowledge building cycle, a main addition to the design-thinking model, helps students reflect on what they know and what they need to know which drives them to seek more knowledge. Asked if they could apply the combined approach in future projects students generally agreed they could *with expert facilitation.*

The facilitators reported that they have little to do in the design-thinking phase of this challenge, the teams "just "got on with it". Aspects of design fixation, latching onto an idea and sticking with it were observed. Facilitator's experience following the introduction of knowledge building is they have more to do. The unified model promotes critical thinking and enquiry so they face many questions. Also, several of the knowledge building principles, scaffolding, maintaining a knowledge-building discourse, and sustaining idea improvement require explanation and reinforcement.

Facilitators observed that using knowledge building principles help keep students in *design mode*, (Bereiter & Scardamalia, 2003), focusing on the improvability and developmental potential of ideas. This demand on facilitators has implications for future studies in terms of their level of expertise and familiarity with leading knowledge building workshops.

Conclusions

Combining the process and practices of design thinking with the principles of knowledge building does appear to assist sustained idea improvement and student, (novice designers) creativity and innovation. The aims of the *Titanic* challenge were to communicate the concepts of design thinking and knowledge building, why it makes sense to combine the two methodologies and illustrate what this means in terms of increased concept innovation. Teams using a design thinking methodology propose typically 2-3 solutions which if successful would, in theory, save over 700 additional passengers and crew by ensuring lifeboats were filled to capacity and by framing the problem as one of keeping people out of the water and constructing prototype floatation devises. Teams using the combined approach produced more innovative ideas, (typically 5-7 additional ideas), to develop solutions that may save, on average, over 1,500 additional lives, almost all passengers and crew. This indicates subsequent knowledge gathering can enhance creative problem solving. This is achieved by critiquing the status quo, making effective use of expert sources as a starting point to close gaps in knowledge, reframing the problem at a deeper level and scaffolding knowledge to improve ideas. Our conclusion is that teams using the combined approach work *creatively with knowledge.* Generating ideas using a design thinking methodology comes naturally to most student teams however, as Scardamalia & Bereiter, (2006), have pointed out, sustained idea improvement does not. The source of innovation lies not just within creativity and stated needs but also in how teams use knowledge to collaboratively improve ideas. The *Titanic* case is an engaging one and appears to facilitate the communication of the design thinking and knowledge building concepts, and the value they bring to each other.

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One Bloody Thing After Another: Barriers to Knowledge Building among Hematopathology Residents in Two Countries

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Abstract: We discuss a new online course in a sub-discipline of medical pathology called *hematopathology*. A form of course called unknown case studies was replicated online and students used virtual microscopy to study blood and tissue samples, along with ancillary data provided by the instructor. This course was jointly offered by an institution in Toronto and in Nairobi, the latter lacking sufficient numbers of qualified instructors on site.

The course was successful and the students reported satisfaction with both the online mode of delivery and the use of virtual microscopy as a way of presenting the medical evidence. However, knowledge building, an expected part of the learning process, did not proceed as expected.

Barriers to knowledge building included issues of anonymity online; frequency of online postings; task queuing problems; unfamiliarity with the online environment and manner of working; and reluctance to post ideas online.

Despite these, students evidenced interested in the course material and felt that this method of course delivery was a valuable adjunct to their learning. Overall the course was successful.
Keywords: Hematopathology, online learning, knowledge building, virtual microscopy.

Introduction

In medical education, one common course structure is the *unknown case study* design in which medical students are presented with relevant data from a case that is unknown to them and they are asked to build a diagnosis based on this (Christensen *et al.*, 2017). Christensen *et al.* (2017) describe a common case structure which,

> **…** is comprised of a list of case histories and glass slides stored at a central location, which trainees preview to create a list of potential diagnoses. A moderator subsequently presents either static images of these slides or reviews them real time, followed by the trainee's differential and favored diagnosis for each case**.** Once the final diagnosis is revealed and the conference ended, the moderator leaves with their presentation and the glass slides, the trainees leave with their differentials, and the institution has lost the educational content of the discussion.

This paper reports on a study in which an attempt was made to replicate this course structure online in a knowledge building manner using Knowledge Forum (Scardamalia, 2004b) as the course delivery platform.

Area of Medicine Under Study:

Hematopathology is a medical sub-specialty of pathology that deals with the diagnosis of disease through the study of blood and related tissue samples. It is a highly visual discipline in which some of the data are presented in the form of glass slides of blood and tissue samples (called blood smears and biopsies) that are examined under a microscope. To properly train residents in this specialty field, medical educators must train residents to analyze the microscope data, integrate it with other relevant data such as clinical history and ancillary testing and make correct diagnoses. The unknown case studies classes are used to train the residents and to informally measure the residents' competence (Christensen *et al.*, 2017). Usually the number of residents in a class is ten or fewer at any one particular institution.

Hematopathology case studies require a large number of minimum slides to view and/or ancillary case data in order to create an effective diagnosis. Normally the microscope slides are physical glass slides. It is difficult to share glass slides across institutions as these cannot always be duplicated, breakage is always possible, and there are privacy issues about tissue samples. These factors limit collaboration among institutions and across programs. However modern imaging techniques allow for high-quality images of the glass slides to be digitized and create the possibility of a web-based virtual case study approach that can be used among geographically disparate institutions and groups of residents.

In order to create a virtual case study course, comprehensive teaching sets of slides need to be digitized for the residents to use (Dee, 2009). Such teaching sets are currently rare and were not available at the two institutions (Toronto and Nairobi) that participated in this study. Anecdotal evidence from end-of-rotation residents (Toronto) indicates that current archived teaching sets are insufficient , In Nairobi, there is a shortage of hematopathologists to teach and a similar lack of archived slide sets.

Dee summarized the advantages and disadvantages of virtual microscopy (Dee, 2009). Ease of access and access to rare teaching materials were advantages, as were the absence of time limits and enhanced group discussions centering on a large display that can be seen by all participants. Disadvantages included the students' loss of facility with physical microscopes, inefficient focusing of virtual images and inadequate image resolution.

Tian (2014) studied two groups of Chinese medical students: one using only virtual microscopy and one using only traditional microscopy. Pre-test scores for both groups were equivalent; post-test scores showed improvements in the virtual microscopy group in case analysis and tissue identification. This 150provides support for the use of virtual microscopy in resident hematopathology education.

Kumar *et al.* (2004), studying Australian students, found that they rated virtual slides as useful for cooperative learning, supporting the idea that virtual microscopy enhanced group learning.

There is also work underway to create digital archives of hematopathology case data. Roth *et al.* (2015) created a 200-case data set over a one-year period, consisting of a comprehensive set of virtual microscope images and ancillary case data. Other virtual teaching sets exist but no current model simulates virtual course delivery in unknown case style.

In sum, there is support for the use of virtual microscopy in medical education, and digital microscope images can be web-based. At present the literature shows no research on the effect of virtual hematopathology teaching sets on resident learning, assessment of learning in hematopathology has not been studied, and no literature addresses the use of virtual unknown case study courses in pathology.

The above gaps in medical education led to the creation of a virtual unknown case study model using digitized microscope slides and having an assessment of learning component. The pathologist-instructor would use the virtual case studies for collaborative learning and analysis in an online web-based forum with learners from geographically disparate institutions.

Research Question:

Would a web-based virtual microscopy hematopathology unknown case conference series enhance pathology residents' perceptions of their learning of hematopathology?

Methodology

There are different kinds of residency programs whose curricula include hematopathology. In this case, there were three: *Hematological pathology* (HP) residents (Toronto,) and *clinical pathology* (CP) and *anatomical pathology* (AP) residents (Nairobi.) All groups study hematopathology, but differ in the extent of study. Nonetheless, all groups need to be familiar with common aspects of hematopathology. Residents in both Toronto and Nairobi were similar in clinical knowledge and diagnostic skill.

After obtaining ethical permission for the research from the institutions involved, participants from both Toronto and Nairobi were recruited via email. Nineteen residents agreed to participate; five from Toronto and 14 from Nairobi. We obtained informed consent from all participants. One resident withdrew consent and was not included in the study.

The course took place over an eight-week period through May-July, 2017. RM chose eight cases for the unknown case conferences–one case per week. Four of these cases were chosen from the American Society for Clinical Pathology (ASCP) *Checkpath* series. The remaining cases were selected from the University of Toronto's Digital Laboratory Medicine Library slide sets. These eight cases were chosen based on an appropriate level of difficulty and non-obviousness.

Knowledge Forum was chosen as the online delivery platform, chosen for its built-in supports for idea sharing, discourse and knowledge building. Discourse and knowledge building are an important part of unknown case study, and we wished to recreate that in this course (Scardamalia, 2002, 2003; Scardamalia, 2004b).

Knowledge building was expected to be an emergent property of the course, as has been seen before when students engage in online discourse around real-world problems (Scardamalia & Bereiter, 1991, 1992). At first, students were to be encouraged to build onto the postings of others with critical comments and suggestions, and then other aspects of knowledge (the 12 knowledge building principles) would be gradually introduced (Scardamalia, 2004a).

We created a Knowledge Forum database with an administrative Welcome view and eight views for the various unknown cases. As well there were administrative views for useful links and other information. Figure 1 shows the Welcome View.

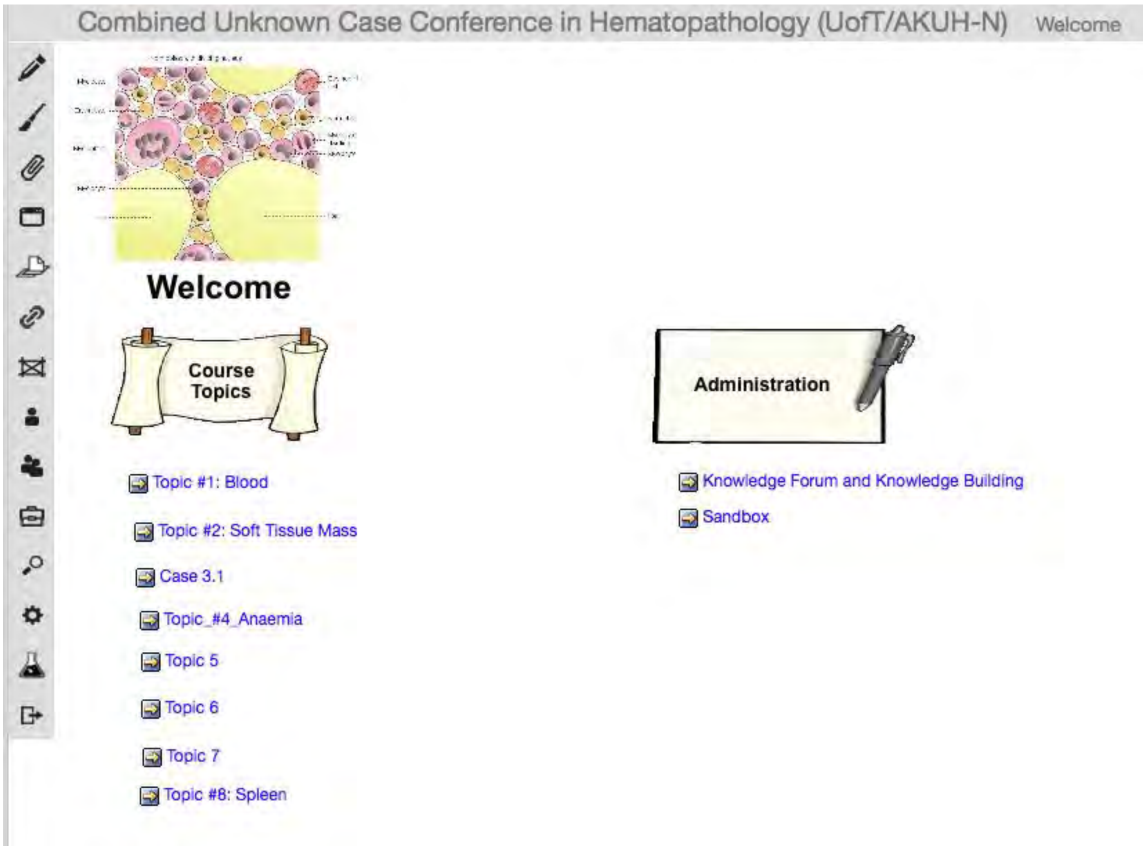

Figure 1. Welcome View from the Hematopathology course.

The course followed a regular rhythm: Each Monday the at each institution were emailed a prompt to view the clinical details that had been entered into that week's view in *Knowledge Forum*. In seven of the eight cases, this included links to a combination of virtual microscopic images of blood films, bone marrow aspirates and trephines, tissue slides and immunostained slides. In some cases, flow cytometry dot plots were also provided; in cases where zoomable virtual images were unavailable, RM provided photomicrographs.

The instructions to the residents were simple:

- After viewing the initial case details and visual data, they were to describe the morphology of the case, comment on potential malignancy and provide a tentative differential diagnosis.
- Following this, on the Wednesday, additional diagnostic clinical test information, ancillary test results or additional immunostained image(s) were posted for applicable cases. This mimics the actual medical practice in which initial information is gathered and then additional tests and studies requested by the clinician. There is a lag time between initial presentation of real cases and the availability of additional test data, and the unknown case study method mimics this.
- The students were then asked to provide an improved diagnosis.
- On the subsequent Friday, the instructor provided the final diagnosis and there was a discussion of the results.

Residents were encouraged to post any questions or queries they had in *Knowledge Forum*, as well as posting their differential and final diagnoses, suggestions for additional tests, etc. They were additionally encouraged to respond to the questions and posts of others with answers and critical analyses. Participation was asynchronous and could be accessed anywhere over the internet.

Due to small numbers of participants, assessment was qualitative. At the end of the course, participants were surveyed (adapted from Tian *et al*. (2014) and mostly passed on a five-point Likert scale.) Semi-structured focus group interviews were conducted at both institutions by the instructor's designate (DP) to gather feedback on the study and to determine residents' perceptions of its impact on their learning. Recordings of these were transcribed for thematic analysis and analyzed using the *NVivo* 10 qualitative analysis program.

Results

We received thirteen survey responses out of a possible eighteen. The focus group interviews were well-attended, with all five Toronto residents participating and ten of the Nairobi residents participating. Emergent themes from the survey and interviews included …

- Level of interest in the study and its content,
- Acceptability of the instructional method,
- Participation in the study, and
- Enhancement of learning.

Interest

All residents in both universities found the online course worthwhile and expressed interest in such courses becoming an ongoing part of their learning. Some residents would have preferred the course to be more closely-tailored to their area of specialty as they felt that not all cases were universally applicable to their areas. However, others appreciated the opportunity to gain exposure to other areas of hematopathology. Overall, sixty-nine percent agreed that they were interested in the topics covered in the online course.

Acceptability

Students were generally comfortable with the technology (sixty-two percent) and found the use of virtual slides convenient (sixty-nine percent.) Sixty-seven percent found the design of the course helped keep them focused on the subject matter. Among the Canadians, residents unanimously found the online case conference convenient due to its asynchronous nature and being supplementary to other teaching in their program. Some Kenyan residents appreciated the ability to see different response styles from residents geographically distant and in different pathology subspecialty training programs.

Learning

Residents all agreed that the virtual cases enhanced their learning. Online posts were not graded and residents decided for themselves the correctness of their interpretations based on the instructor's final diagnosis and the online discourse. When questioned about how they rated their diagnostic ability, sixty-nine percent were neutral.

Eighty-nine percent of the residents said that the course facilitated effective learning.

Participation

Figure 2 shows the total number of notes posted by each participating student.

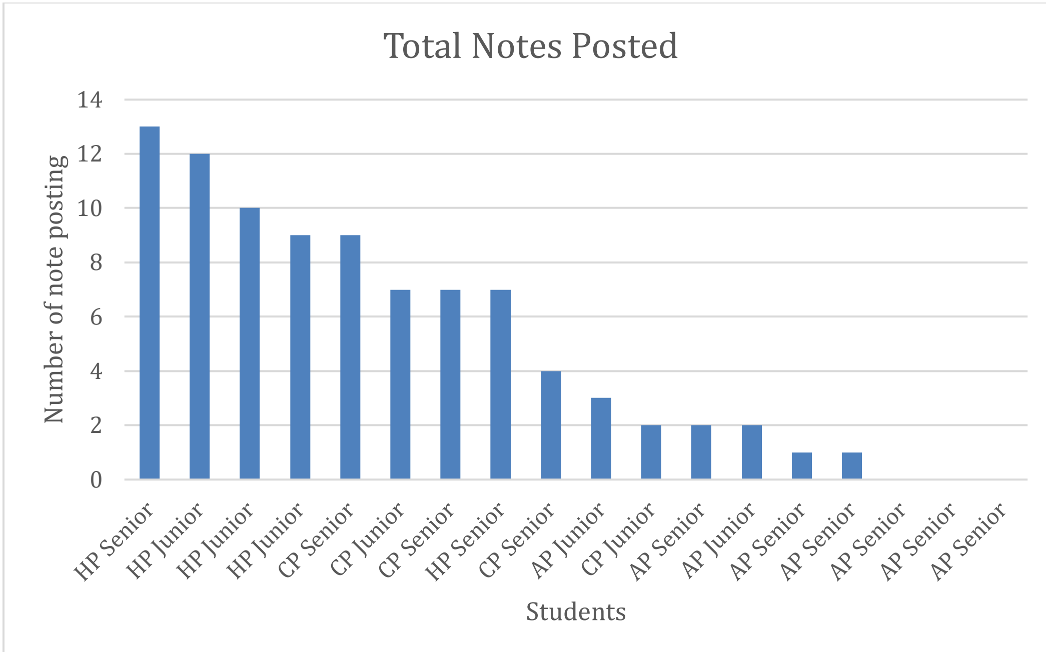

Figure 2. Total notes posted by each student (sorted data.)

Figure 2 reveals a problem. Although most students reported that they were comfortable with the technology, that the course method of delivery was good and that this enhanced their learning, almost half of the students participated minimally or not at all in the online discourse. However, as shown in Figure 3, the level of note reading among the group was high.

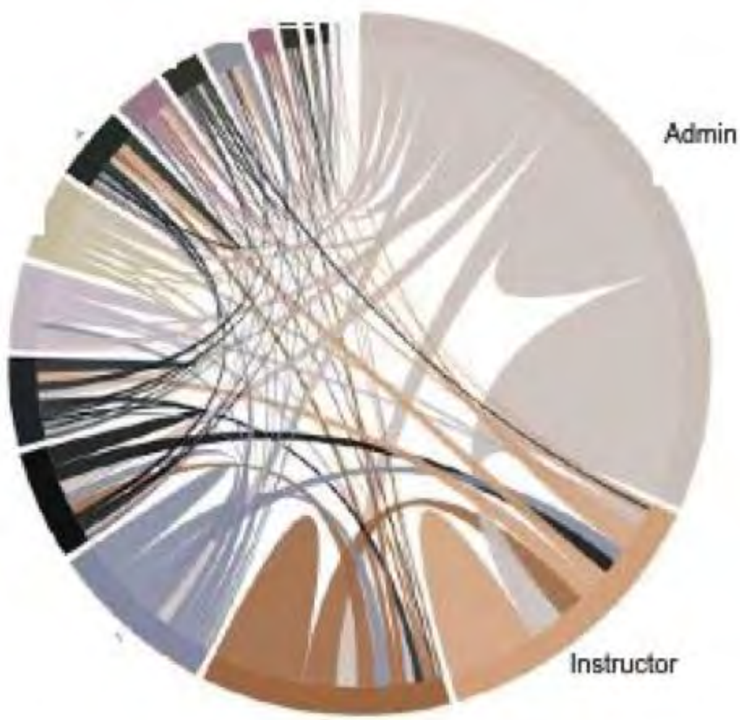

Figure 3. Reading Network showing cumulative note reading over 8 weeks of cases. A colored band identifies each resident. The width of the band indicates the frequency of activity. Admin = technical builder of the case on the platform.

These results indicate that the students were quite happy to read the note postings of their instructor, administrator and fellow students, but were hesitant to post their ideas online themselves. One student commented, "*I would say there was minimal interaction. But it was definitely helpful reading the notes.*"

Responses (build-on notes) were also a problem. What we saw was a pattern of reading and responding to the instructor/administrator notes, and reading other students' postings, but a great reluctance to posting a response to the postings of other students. As well, there were more responses to the second set of information (posted on Wednesdays) than to the initial information, even though the instructor had told the students that she specifically wanted postings to both the initially-presented information and the later supplemental information. The students were aware of their lack of interaction, with one commenting,

> *I didn't respond to any of the notes but if I was thinking about something then I go to maybe look to see at what other people had written to see if I am on the same lines or am I totally out so that I can revise. But it was really helpful to see the tissues - the lymph nodes and spleen. It was helpful to see what other people had written because they have more experience than I do.*

One student commented that they felt that the interaction would have been better in a live-class setting. However, another disagreed and made a comparison to online social media, noting, "*But no you can comment. Lots of social media is like that. Student: you know you leave your comment with the pencil* [editing tool] …" This indicates that the students were quite well aware that they could respond to other students and were apparently comfortable doing so on social media.

Anonymity again raised its head in a different form in some comments. Some students felt more comfortable responding to students they already knew and were reluctant to respond to students they didn't know. One student commented that to give a response, "*I immediately would go to the person I knew and see what [she] is saying ... I never really commented to people I don't know*."

Other issues raised by students were content, specifically the level of difficulty; time and workload (raised by both Nairobi and Toronto residents); and a need to better prepare students for what online courses entail (one student suggested needing a mentor).

Another factor in participation that was important was the problem of *bursts* of activity. A number of students referred to how busy their week was and that they therefore planned out their week. Knowing that the final diagnosis was due on Friday, the students waited until late in the week to work on the hematopathology course. One student noted,

> *I think it has to do with how you have your routine week planned out and what other course stuff you have to do and training at the bench and service work so it gets to the end of the week and you're like there's an online case that I have to do for Friday. You find you're doing it Friday afternoon.*

This comment is in line with findings by Barabási (Barabási, 2005, 2010), who noted that, "... whenever an individual is presented with multiple tasks and chooses among them based on some perceived priority parameter, the waiting time of the various tasks will follow a Pareto distribution" (205, p. 209). Simply put, this means that people will queue up their tasks according to their priorities and do their work in bursts of activity relating to when those tasks need to be done. In this case, waiting until shortly before the due date was not uncommon.

Discussion

Most students felt that the unknown case study style of delivery, including the virtual images and *Knowledge Forum*, was an acceptable adjunct method of learning. One CP resident commented,

> *I did find it worthwhile. There are cases I probably would not have read on my own. I had to actually, for the first time, find an AP to teach me how to look at a lymph node and learn through it and actually did a lot in terms of posting the little hematopathology that I have. So actually I would like to have more cases.*

Another resident noted, *"It supplements a lot. We are used to the live sessions of teaching [where] you know we can only really get a limited amount of teaching in a limited amount of time".*

Residents, always very busy, found this style of course delivery convenient,

> *The convenience of time, whenever you want to do it and the opportunity to do some reading around it and to see other comments–that also was nice because you could see what other people think about and how they approach things as opposed to having it live where you don't have that much time to do those things.*

Of significance to the attempt to get true knowledge building working among the students was the problem of minimal online interaction among the students. As noted earlier, note reading was robust and dynamic, but note posting could at best be described as anaemic. A few problems in this regard were identified.

First, anonymity proved to be a problem. Although the students were instructed not to use their real names when registering on *Knowledge Forum*, most found the instructions confusing and registered under their real names. Residents noted that the resultant lack of anonymity resulted in decreased levels of posting. While this could have been remedied by more clear registration information, some residents didn't feel that anonymity was very important. One reported,

> *I think it is good to have names. I have this experience from Twitter. When you look at Twitter you see people from North America, from the USA, from the Middle East, from different areas and sometimes I learned from people from Italy - they have some comments on a case or they post pictures from a case…and you look at the descriptions and you learn from that and you can also give comments. I think it is good to have names and to have a discussion. That would be very helpful.*

However, as noted above, anonymity was a two-edged sword: Students were shy about posting notes themselves, but felt they learned from the students who did post notes. As well, some students liked to have the names of the participating students, but this also apparently caused some students to limit their participation to students they already knew.

A second barrier to effective knowledge building participation was the level of interest in the course material among the various sub-disciplines among the hematopathology residents. The initial assumption for the course was that there would be equal levels of interest in, and that residents would devote equal amounts of time to, the various cases presented. This proved not to be the case, with the highest participation among the HP residents, followed by the CP and AP residents.

A third barrier to effective participation was the timing of the course. Kenyan university residents preferred to work on the course materials over the weekends, but the course had been designed to run Monday-to-Friday. As a result, the Kenyans participated less. This issue could be easily fixed by extending the course to encompass the entire week.

A fourth barrier proved to be the timing of the presentation of the additional materials. In live-class settings, the instructors control this, and can demand immediate responses from the class to both the initial materials presented and to the later test results and other supplementary materials. However the online course was asynchronous, and the students almost immediately realized that they didn't need to respond to the initial information–they could simply wait until Wednesday for the supplementary materials and give a better diagnosis. This bypasses an important step in the diagnostic process, one that would be present in a real-life setting. One student noted,

> *You start answering when additional information has already been given so you are already biased. You have missed out the first half of that particular assessment. It should be modelled in such a way that you can't get the second part of the information unless you've answered the first part.*

In future course designs, the instructor might wish to wait until all (or at least most) residents have posted an initial diagnosis before presenting the additional information. The instructor might also work to promote discourse among the group by asking generative questions such as, "What further information or tests would you need to confirm your diagnosis?"

Finally, there were a number of smaller barriers that contributed to less-active knowledge building: Students prioritized their hematopathology work for late in the week; they initially felt insecure and unsure how to proceed in online classes; and the technology *wasn't* difficult to use but *was* new. While many of these barriers are common to other forms of online learning, their presence added to a reluctance to post and participate in a knowledge building manner.

Conclusions

The course worked; the students learned. Using the same measures typically used for face-to-face classes, the results achieved were similar. Virtual microscopy was demonstrated as a valid approach to teaching hematopathology and the use of online technology was validated. The course was able to provide remote instruction to an area where sufficient qualified instructors were not physically present and students in two geographically disparate locations were able to learn together.

Nonetheless, things could have gone better and the students could have learned more deeply had knowledge building proceeded as planned. Yet none of the barriers to knowledge building were physical (infrastructure, etc.) or technological–all were social. Some of these barriers will be difficult to overcome for a course of short duration. For example, students wanted anonymity for *their* postings, but also indicated that they wanted to know who the *other* posters were, and in fact preferred to interact with those they already knew in person. It would not be possible to provide both conditions. Likewise, it takes a little time for students to accustom themselves to the online environment, but being very busy, they object to spending time online just learning the environment and practicing with it.

In future, it will be possible to make the course expectation clearer (especially the expected frequency of postings and responses) and to re-structure the course so that there is less of a tendency to post in bursts towards the end of the week. Once the students have a clearer idea of what is expected of them, many of the problems will go away. One possible way to do this would be to explicitly introduce the knowledge building principles at the beginning.

The value of this course is obvious. There are many instances in which opportunities for advanced medical training are limited because of the location of the institution and the lack of qualified instructors. This course demonstrated that it is possible to combine students from different institutions in different countries and time zones and deliver a high-quality course to them. It is hoped that this approach can be expanded in future to include other areas and institutions.

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ViSuAl
The Video supported collaborative learning knowledge alliance Erasmus+ (EU)-project.

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Abstract
YouTube, Vlogging, SnapChat, Skype, smartphones and video in WhatsApp etc. is what youth and adults use in their daily and working life to communicate. We are visual thinkers, observational learners and thus social learners (Bruner, 1961), so using visuals in education has many benefits. However, most teachers do not know how to use videos systematically in teaching (OECD, 2017). Europe-wide, there is a need for competent teachers in utilizing e-learning with leading digital collaboration solutions. The same holds true for pedagogical knowledge of designers in educational technology companies. The potential of video-supported learning has not been opened in teacher education (Hobbs, 2006). Education and companies alike lack pedagogical models and structures to promote learning from and with videos (Krauskopf, Zahn, Hesse, & Pea, 2014)
Video-based e-learning in particular is one of the most emphasized 21st century teaching-and-learning approaches. Showing a video is not enough (Van Gog, Verveer, & Verveer, 2014). However, most teachers do not use video tools in a way that contributes to developing conceptual thinking and problem solving skills as relevant work-life competences of the knowledge worker (Bereiter, 2002). The modernization of European Higher Education Institutes (HEIs) calls for a workable pedagogy and skilled teachers to take on the up-to-date video-supported collaboration solutions for creative teamwork in online environments.
In this contribution we want to explain the ViSuAl-project, which tries to address the previous challenges. In particular, after introducing the project and its reference framework, we will present the first ViSuAl milestone: a state of the art review on video use and collaborative learning.

Introduction
YouTube, Vlogging, SnapChat, Skype, smartphones and video in WhatsApp etc. is what youth and adults use in their daily and working life to communicate. We are visual thinkers, observational learners and thus social learners (Bruner, 1961), so using visuals in education has many benefits. However, it is not the practice. Company partners' product user analysis (150,000 users in European context) shows that majority of teachers use PowerPoint like transparencies with a lot of text while only few use video for reflecting practice. Also, a need analysis by the Alliance and our work with teachers' professional learning groups on e-learning, shows that most teachers do not know how to use videos systematically in teaching (OECD, 2017). Deep understanding of using videos is missing. Showing a video is not enough (Van Gog et al., 2014). The potential of video-supported learning has not been opened in teacher education(Hobbs, 2006). Education and companies alike lack pedagogical models and structures to promote learning from and with videos (Krauskopf et al., 2014).

One structure is given by learning sciences scholars (R. K. [Ed] Sawyer, 2014) showing evidence that students who learn together, in pedagogical approaches such as 'knowledge building' (Scardamalia & Bereiter, 2014), computer supported collaborative learning (CSCL) (Stahl, Koschmann, & Suthers, 2014) and responsive learning (De Jong, 2015), outperform students whose teachers use frontal, 'knowledge telling' pedagogy. However, this does not make CSCL a favorite pedagogy in practice (NMC Horizon Report, 2014). Why? Because of lacking practices in the use of modern ITC technology (Carmen Zahn, Krauskopf, Hesse, & Pea, 2012).

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[4] JAMK Applied University, Jyvaskyla, Finland

A second structure (Grossman et al., 2009) identified three key concepts for understanding the pedagogies of practice in professional education: representations, decomposition, and approximations of practice**.** Today, the use of videos remains mainly on the representations level but efficient models for decomposition and approximations of the practices are needed, e.g. opportunities to engage in practices of a profession. Video visualize various praxis to novices but it needs a breakdown of practice into constituent parts for teaching and learning; The ViSuAL project aims to fill this gap by engaging HEI-research, teachers and companies in developing innovative teaching methods.

Our solution combines two tools: evidence-based pedagogical video use and CSCL into Video-Supported Collaborative Learning. We argue that video can be an excellent tool when combined with collaborative learning(Carmen Zahn, Krauskopf, Hesse, & Pea, 2010)**.** It develops students' critical thinking and problem solving skills that are important for a development of entrepreneurial skills and aptitudes(UNESCO, 2017). Video bridges school and practice, which is important for vocational education and training (VET) and teacher-educators (TE)[5]. The models can be used and teached in TE so that teacher-students become familiar with Video-Supported Collaborative Learning as an educational tool (Gaudin, Chaliès, & Chalies, 2015). Here development together with companies is needed (European-Comission, 2014)[6] to capitalize on the latest video solutions and tools together with workable pedagogical insight.

Working together, HEIs–Teacher Education (HEIs-TE) with companies providing modern educational technology, ViSuAL will give the companies pedagogical insight, models and teaching methods to accompany their products**.** The information exchange and use of each other's knowledge and expertise in this co-creating alliance modernizes[15] teaching and learning of HEI&VET teacher education and thereafter HEI&VET education.

The experimentations carried out in ViSuAL provide workable practices for transforming education. The capacitated teachers are spreading the impact as pedagogical agents throughout their institutions with the help of the educational resources. Moreover, the MESH guide, hyper-video MOOC and Teachers' Manual will provide an easy-start for any teacher education institute looking for workable pedagogical model and practices on video-supported collaborative learning.

In long run, ViSuAL will contribute to meeting the modernization needs of European HEIs by advancing digital skills for learning and teaching. On the pedagogical point of view, we hope to offer the HEIs a vision for modernizing education by exploiting the new technologies in the learning and teaching practice. By supporting the development of digital communication competences of European professionals, ViSuAL will take part in the building of the knowledge-intensive society and competitive digital economy that EU aspires for.

Video-Supported Education Alliance (ViSuAL) is an Alliance of 6 Higher Education institutes Teacher Education (HEIs-TE) and 6 Educational Technology Designers (ETDs). During the three-year project they aim a process of co-creating an evidence-based pedagogical model for Video-Supported Collaborative Learning. Within ViSuAl, video-supported collaborative learning is defined as *the use of video technology, tools and platforms in a way that contributes to developing conceptual thinking and problem solving skills as relevant work-life competences of the knowledge worker.*
In fact, the resulting model will support the development of students' critical thinking and problem solving skills that are important for navigating the increasingly turbulent, knowledge-intensive and entrepreneurial work-life. The model will bridge school and practice, which is important for vocational education and training (VET) and

[5] "While the majority of countries report embedding entrepreneurship education in their curricula, they rarely recommend teachers any particular teaching/learning methods and consequently leave them with great autonomy in this area. Clear guidelines are important for teachers to have a common understanding of what methods are appropriate for education, and which ones will contribute most effectively to the successful teaching of these skills." (EC, Eurydice, 2016) https://webgate.ec.europa.eu/fpfis/mwikis/eurydice/index.php/Publications:Entrepreneurship_Education_at_School_in_Europe_-_2016_Edition

[6] **2a:** (p10); **2b**: (p11); **2c:** recommendation 2 (p28); **2d**: *"it is about acquiring skills that are essential in the labour market and, increasingly, simple for every day life"(*p31); **2e**: Recommendation 2: "promote experimental partnering with specialist service providers"(p28); **2f***: "There is not yet a full understanding of the positive impact that new modes of learning and teaching can have (..).* (P16); **2g**: (pag 19).

teacher-educators (TE) as well. Furthermore, it will encourage video content creation and sharing as a rising work-life competence. The model will be used and taught in TE so that teacher-students become familiar with Video-Supported Collaborative Learning as an effective educational strategy.
Apart from the model, the following additional ViSuAL **outputs** will aim at a sustainable HEIs-TE&ETDs collaboration:

1. **An evidence-based hands-on pedagogy to utilize video-supported collaborative learning.**
2. **Hands-on principles for a sustainable HEIs-TE and ETDs co-creation partnership**.
3. **Pedagogical design principles and workable pedagogy practices for ETDs to enhance use of their products in education.**

The diversity of ways in using videos corresponds to different characteristics and potentialities of the different products, services and technologies. Similarly, it also corresponds to very different pedagogical models and classroom practices. We list some of them:

1. *The informative video:* typical of the lecture capture approach, it is usually an instructional video with the characteristics of being
    a. knowledge broadcasting oriented;
    b. produced by professionals or teachers;
    c. content- and teacher- centered.
2. *The active learning video*: as in the previous category, the video use is designed for teaching purposes and includes teacher talks and explanations, animations, simulations, but also self-learning and evaluation activities as tests and quizzes, or student-made annotations, for educational purposes. This kind of video is generally
    a. knowledge acquisition and reproduction oriented, but can also be semi-collaborative (for instance in case of peer feedback) and can become collaborative when collective or community dialogue is added;
    b. produced by professionals or teachers but finally including materials added by students;
    c. content- and learning-task/assessment- centered.
3. *The (knowledge) experience/building video:* this third category usually takes the form of vlog, narrative, simulation recoding, video-supervision (progressive) inquiry vlog, and it mainly supports reflecting, (collective, community) dialogue and discourse. This kind of video is characterized by being
    a. knowledge building/creating oriented. Aiming at enhancing professional practices and skills through dialogue and reflection after real and/or simulated practices, its use is usually grounded in approaches like experiential learning, collective learning, progressive inquiry learning, collaborative learning.
    To increase its potential of knowledge building, this kind of using video is often associated with sharing mechanisms within professional communities.
    b. (individually or collaboratively) produced directly by learners. The use of video aims at collaborative learning, as for example, video storytelling and interactive video or hyper-video.
    c. conceptual development-, idea improvement-, student- centered.

This third kind of video use is the one the ViSuAL project wants to focus on by strengthening it with the collaborative learning pedagogy and especially with the knowledge building pedagogical approach/model.

The project started January 2018 and one of the first deliverables is a state of the art review on video use in education and collaborative learning. A second paper presentation is dedicated to this specific point.

The literature state of the art review

This literature review is conducted in the context of a *Knowledge Alliance (KA). A KA is an European* partnership (VISUAL project) between higher education institutions and companies in the field of educational technology. In particular in using video technology, tools and platforms to support professional development in different contexts such as teacher education and training, VET education and primary education. This literature review is only one of the procedures that we will use to get a full understanding of the use of video supported for supporting both professional development and video based collaborative learning. The other procedures includes lead users interviews from the different companies' products and services, pre-experimentation interviews and needs analysis. With all these procedures, we intend to identify the gaps related to pedagogical skills and methodologies in order to facilitate collaborative learning and professional development of the target population using the educational video supported materials.
?

The main topics and concepts involved in this study are as following:

Video-supported collaborative learning: for this concept we want to mean the use of video technology, tools and platforms in a way that contributes to developing conceptual thinking and problem solving skills as relevant work-life competences of the knowledge worker.

This diversity of ways in using the video it corresponds to different characteristics and potentialities of the different products, services and technologies. And this also corresponds to a very different modes of using pedagogical use of video technology, in terms of pedagogical models and classroom practices.

1.1 Video recording for professional development. These modes of using video technologies is to enhance professional practices and skills through dialogue and reflection after real and/ or simulated practices and eventually shared within professional communities.
1.2 *Video content creation and sharing* .These modes of video uses are those uses of video for collaborative learning, as, for example, video storytelling and interactive video or hyper video.
*1.3 Interactive video content: these modes of using video are designed for teaching purposes and includes teacher talks a*nd explanations, animations, simulations, self-learning and evaluation as tests and quizzes, for educational purposes.

The main challenge of the project is to understand how these different ways of using video technology and tools can be used and integrated into the pedagogical perspectives as knowledge building and models for collaborative learning. Research Question: How video technologies and tools have been used for supporting collaborative learning in order to facilitate professional development.

Method

The methodological approach includes five stages that guide the review design: (1) problem identification, which ensures that the research question and purpose are clearly defined; (2) literature search, which incorporates a comprehensive search strategy search; 3) data evaluation, which focuses on the authenticity, methodological quality, informational value and representativeness of the available primary studies; (4) data analysis, which includes data reduction, data display, comparison and conclusions; and (5) presentation, which synthesizes findings in a model that comprehensively portrays the integration process and that describes the implications for practice, policy and research as well as the limitations of the review. (Hopia, Latvala, & Liimatainen, 2016, p662/3). A structured literature review procedure was followed, in seven steps, as suggested by Cooper, (2010, p.65).“Step 1: Formulating the problem; Step 2: Searching the literature; Step 3: Gathering information from studies; Step 4: Evaluating the quality of studies; Step 5: Analyzing and integrating the outcomes of studies; Step 6: Interpreting the evidence; Step 7: Presenting the results.
Four main criteria for literature review inclusion were established: content, scientific criteria, language and chronological period. The literature review includes articles, chapters and book/dissertations that refers to pedagogical models for facilitation of professional development via video supported collaborative learning and co-creation processes in development education. In terms of scientific criteria, chronological period and language, and where possible, the papers have been peer-reviewed, published after 2003 and published in English language.
The documents search was limited to the adequate educational databases. The following databases were searched: ERIC (available: https://eric.ed.gov); Educational research complete (available : https://www.ebsco.com/products/research-databases/education-research-complete); Psyndex (available: https://www.psyndex.de/index.php?wahl=PSYNDEX&uwahl=Angebot&lang=EN);
Psychinfo (available: https://www.ebsco.com/products/research-databases/psycinfo
The following search string was used for search the above mentioned databases and is as follow:
(((video) AND ((Collaborative learning) OR (collaboration)) AND ((professional development) OR (teacher education) OR (teacher training) OR (vocational education) OR (professional education))).
Criteria for inclusion
Four main criteria for literature review inclusion were established: content, scientific criteria, language and chronological period. In the content criteria, the literature review to be conducted will includes articles, chapters and book/dissertations that refers to pedagogical models for facilitation of professional development via video supported collaborative learning and co-creation processes in development education.
In terms of scientific criteria, chronological period and language, and where possible, the papers should have been peer-reviewed, published after 2003 and published in english language.

Analyzing and integrating the outcomes of studies was a task made step by step. First organizing data in order to prepare the collected information in formats that also facilitate data codification and analysis. Then, and in taking in consideration the fields used for data collection, we made a first and exploratory analysis within all the records of the reviewed material. As a result a detailed set of sub-categories and correspondents coding numbers was done in order to get all the material organized in numeric our textual data and facilitate different kinds of analysis. This resulted in 474 publications before discarding duplicates and 363 without duplicates.

The coding operation on the content of the reviews was done by 4 researchers in order to obtain more accurate results.

Coding table

Categories	*Description of sub-categories and correspondent coding numbers*
Topics and concepts	*Areas of Knowledge* *1. Initial Teacher Education* *2. Teacher Training and Professional Development* *3. Higher Education* *4. Elementary Secondary Education* *5. Vocational Professional Training Education* *6. Multiple areas of knowledge*
Participants	*Type of Participantes* *1. Student Teachers - pre-service/prospective or initial* *2. In-Service Teachers - elementary and secondary teachers* *3. Teacher trainers - elementary and secondary education* *4. Teacher Educators - initial teacher training* *5. Teachers/Instructors Vocational education* *6. Vocational Students - trainees* *7. Student-teachers+teacher educators + in-service teachers* *8. Student teachers and teacher educators* *9. Instructional designers* *10. Higher Education Students* *99. Information not available* *Region where research took place* *1. Europe* *2. America* *3. Other* *99. Information not available* *Number total of participants in the research* *1. <25* *2. 26-50* *3. 51-75* *4. 76-100* *5. >100* *99. Information not available*
Target-groups /areas	*1. Student Teachers* *2. In-Service Teachers* *3. Higher Education Students* *4. Teacher trainers* *5. Teacher Educators* *6. Vocational Students* *7. Instructors Vocational Teachers* *8. Instructional designers* *9. Student Teachers + Teachers Educators* *10. Teachers educators + in service-teachers* *11. Student Teachers + In Service Teachers + teacher Educators + teacher trainers*

	12. Higher education teachers *13. Other* *99. Information not available* *Note: teachers educators=pre-service teachers* *teacher trainers= teachers who train others (teachers but also others professionals) in secondary, vocational or other type of education and training organizations or corporations*
Research method / Type of research	*1. Qualitative research methods* *2. Quantitative research methods* *3. Mixed methods Research*
Data collection	*1. Using video as data collection tool* *2. Interviewing* *3. Observation* *4. Informal conversations* *5. Questionnaires/Surveys* *6. Content analysis* *7. Self-assessment tests* *8. Pre-post tests* *9. Field notes* *10. Multiple quantitative data collection* *11. Multiples qualitative data collection techniques* *12. Logging data and Portfolios* *12. Learners artifacts* *13. Texts and documents* *14. Other data collection tools* *99. Information not available* *[Multiple answers possible]*
Used video technology	1. Using web video conference systems 2. Using video recording /display systems 3. Using mobile video systems 4. Using Telephone 2 way 5. Using DVD 6. Using Audio system 7. Other video technology used 99. Information not available
Type of device	1. Using web video conference systems 2. Using video recording /display systems 3. Using mobile video systems 4. Using Telephone 2 way 5. Using DVD 6. Using Audio system 7. Other video technology used 99. Information not available
Video modality of usage	1. Video is used for capturing and recording professional/teaching practices [for training and professional learning development - through observation, analysis, discussion and reflections] own or other's. 2.Video is used for teaching/instructional purposes, including interactive/hyper videos, the use of online video platforms and the use of interactive video tools as video annotations tools; 3. Video is used to support learners centered perspectives, through the learning of processes of video creation/production/edition. 4. Video is used to support teaching and learning processes using web based video conference systems

	5. Video is used in a diverse and multiple video modalities to support education, training and professional development. 6. Other video usage modalities
Pedagogical perspective and approach	1. Using video as content resource and material for teaching and learning purposes 2. Using video recording practices - own or others - for teachers professional development including feedback, observation, examination, analysis and reflection, in a individual or group base. 3. Using video recording practices for acquisition and development of professional/ vocational skills and competencies. 4. Using video processes as capturing, recording, creating and editing video in a constructivist perspective, including knowledge building and collaborative learning. 5. Using video for web based conferencing 6. Using real time or streaming video of authentic and learner centered environments 7. Multiple pedagogical perspectives in using video. 8. Using video data collecting for analysis and research 9. Using video in a dialogic peer coaching, including peer critique and collaboration 10. Other pedagogical perspectives 99. Information not available

Results & Conclusion

The first layer of the analysis of literature reviews shows five different ways of using video for support collaborative learning: video recordings, video creation, video content display, video as a communication tool and using video in a combined way, meaning using video in multiple modalities.
A second layer show how video for collaborative learning has been used in four different educational contexts: in-service teacher education, initial teacher education, vocational and professional education and elementary and secondary education.
A third layer of analysis was focused on a deep understanding of how video has been used for supporting collaborative learning, finding what learning designs has been used, through what learning experiences, activities and practices (or what pedagogical models had been used) and how literature review reveals the fundamental learning design principles, contributing to a shared evidence based knowledge which can be used to support possible recommendations for each of the previewed educational contexts where VISUAL project will be developed.

Effective learning designs' and their quality benefits from an understandable and rigorous descriptions within educational contexts, which, in this case, are: teacher education, vocational and professional education and elementary and secondary education.
In this context this literature review thirteen pedagogical models for facilitation of professional development were reported in the literature when using video for support collaborative learning in the identified video modalities of usage.

1. *Model for support collaborative learning through teacher's video clubs:* groups of teachers observe, discuss and reflect about each other's' classroom practice, regularly (Cockburn, 2010).
2. *Model for support collaborative learning through the use of video traces*: video from trainee's classroom practice to view, discuss and analyse collaboratively with their peers, veteran teachers and university teachers (Bier et al., 2012).
3. *Model for support collaborative learning through the use of teaching video cases*: video recordings showing authentic and complex realities of classrooms in ill-structured domains of teacher education and initial teacher education (Goeze, Zottmann, Vogel, Fischer, & Schrader, 2014)
4. *Model for support collaborative learning through teachers video clips*– short videos from reflections of teacher's own teaching practices serve as anchors for collaborative discussions, providing positive and valuable individual conditions for teacher changes of classroom practices (Gröschner, Seidel, Kiemer, & Pehmer, 2015)
5. *Model for support collaborative learning through The Problem Solving Cycle* (Borko, Jacobs, Eiteljorg, & Pittman, 2008) Video recording of teachers' own practices as a model for PD , embedded in the Problem Solving Cycle which is an iterative, long-term PD approach (developed in mathematics education) that focuses on specialized content knowledge and the pedagogical content knowledge of teachers (Bull et al., 2007)

6. *Video Stimulated Recall* model (VSR) which is a collaborative supervision model which involves a supervisor and prospective teachers collegially reviewing a previous video recording lesson or practices - a videotape of a lesson- or particular sections of the lesson, while identifying specific occurrences for discussion(Kelting, Jenkins, & Gaudreault, 2014).
7. *Model for support collaborative learning through the Interconnected Model of Professional* Growth – the model allows to use video-supported collaborative reflections based on the video recordings of teachers own practices.
8. *Model for support collaborative learning through action-research teacher's involvement* - within this model, teachers use video recordings of their teaching practices and engage in a weekly peer group collaborative reflection sessions, collaborate with students, and consult with other sources to identify goals for improving their teaching practices, develop action plans, and analyze the results of their actions. This action research model provided opportunities for self and collaborative critical reflection that challenged each of the teacher's traditional methods. Collaboration with peers and students was crucial at each stage of the action-research process for these science teachers (Tuma, J. M., & Pratt, J. M. (1982). Clinical child psychology practice and training: A survey. \ldots of Clinical Child & Adolescent Psychology, 137(August 2012) et al., 1994) (Lebak & Tinsley, 2010)
9. *Model for supporting collaborative learning through video sharing in an online professional learning community* – within this model teacher is invited to recording their own teaching practices and uploading videos to an online video database in the field of Teacher Education. These videos can be used within an online professional community for sharing, self-observation, collaboration and reflection (Lebak & Tinsley, 2010).
10. *Model to supporting collaborative learning and as data collection instrument model*- within this model teachers, researchers, students and parents learn with each other and collaborate using video technology. Multimodal video analysis, classroom observations, interviews and informal conversations with teachers, children and parents are used for data collection source but also as a source for analyzing teachers own pedagogical practice in the classroom (Davidsen & Vanderlinde, 2014).
11. *Model for supporting collaborative learning and knowledge building using video creation and editing*– this model is best used as a fundamental resource embedded within students' centered pedagogical perspectives – project based learning, inquiry-based learning i.e. where students became producers and collaborators (de Berg, 2016) and also authors and developers in an online community of e-practitioners based on virtual learning environments (Larsen, Sanders, Astray, & Hole, 2008). The model involves different types of learning experiences as "both learning and teaching are considered active processes of constructing and reconstructing knowledge, skills, values and attitudes from previous and new experiences that participants share in the learning environment". Students centered pedagogical approaches as problem-based or task-oriented learning, cooperation, interaction and dialogue among students and teachers, self-reflection on learning as a tool for professional development, transparency and evidence-based writing are some the learning activities reported within this model.
12. 12. *Model for computer supported collaborative learning through content video displaying, and interactive/hyper-video.* Research literature in this area consistently emphasizes these potentials of design projects as an instructional method promising to serve several important educational goals at once: the goal of training skills, the goal of building dynamic social relations and of building knowledge (C Zahn, Hesse, Finke, Pea, & Mills, 2005). Within this pedagogical model, video is used to support collaborative learning and knowledge building through different types of activities using computer systems networks technical affordances allowing a non-linear and interactive uses of the video content for navigation, annotation (using bookmarks, links, anchors, taking notes and comments), sharing and authoring tools to promote social and learning interaction possibilities. Learning to observe and learning to analyze as well as learning to integrate text and video - learning to design non-linear information structures (Krauskopf et al., 2014; C Zahn et al., 2005; Carmen Zahn et al., 2010, 2012). are two special dimensions of this pedagogical model for supporting collaborative learning. Different types of teaching and learning processes can be implemented for students as well as for teachers and pre-service teachers, as self-regulated learning, self-reflection tool and producing digital narratives. For teacher education and initial teacher education video can be used to promote observation skills, analyzing and sharing practices and reflections of teachers' videos of their own teaching using individual case analysis, case based learning and collaborative case discussions(Goeze et al., 2014). Video annotations by beginning teachers in the form of written documents can be used to identify goals for improvement and videos to evidence of their progress. Using video annotation was related to professional development goals (McFadden, Ellis, Anwar, & Roehrig, 2014).
13. *Model for supporting collaborative learning using video as a communication tool in professional contexts.* "There is evidence that video technology used synchronously, and particularly asynchronously, can extend the quantity and quality of classroom observation experience, which in turn

supports the development of observation, analysis and reflection in viewers" (Marshall & Simpson, 2014). Within this model video technology is used by in-service teachers, pre-service teachers, tutors, supervisors and students linking teacher professional contexts – classroom practices - to teacher learning contexts using live video to promote reflection, collaborative discussions and the acquisition of a pedagogical language by trainee teachers ((Marsh et al., 2010). Other learning experiences includes using live video for improving teacher's pedagogical competencies in communication or conducting learning processes, mentoring and feedback on their teaching practices. This pedagogical model of using live video were also reported as *live lessons and remote classroom observation,* web based conferences, video conference assisted group, video based conference lectures for teaching and learning purposes using live video technology. *These video modalities can include multi-person video conversations, lives-streaming /broadcasting real-time, live video footage or video feed to an audience accessing the video stream over the internet. It can be just video, audio or both. Social interactions can happen through voice or webcam, videotext chat and twitter feed. In educational contexts live video can be used for broadcasting live seminars, workshops, live-labs, webinars, short courses, group research activities and others.*

The models extent deliberately the use of video uses as was mention in the three layers of video use as described in the introduction. These there user modes where derived from the presentations at the video and education conference in Leuven, Belgium. June 2018. Especially there is much more available on the video and collaborative learning than the conference did show or suggested.
The 'tentative' conclusions from the review of the literature on video supported collaborative learning can be translated into design learning principles derived from pedagogical models for facilitation of professional development via video supported collaborative learning. These design learning principles for video supported collaborative learning will be published in an article (Ramos, et all, under construction; Visual deliverable (internal research report on the state of the art, 2018)) which is under construction.

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Idea Generation and the Shared Epistemic Object of Knowledge in an Artifact-Mediated Co-Invention Project

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Abstract: In Finnish basic education, we are making interventions that engage student teams in collaborative invention (co-invention) processes aimed at knowledge creation. In this paper, we focus on one team of four students aged 13 or 14. We introduce our preliminary findings and a methodological framework designed to analyze and describe 1) the development of design ideas and 2) the shared epistemic object of knowledge that the student team created during the co-invention process. In addition, we seek to describe the role of concrete design artifacts in the ideation process.

Introduction

This paper focuses on the co-invention process of a team of 13–14-year-old students participating in a Co^4-Lab project at Aurinkolahti basic school in Helsinki, Finland. The Laboratory of Co-Inquiry, Co-Design, Co-Teaching, and Co-Regulation (Co^4-Lab) project aims to engage students in collaborative efforts to invent complex concrete or immaterial artifacts, sparking intellectual, technical, and aesthetic challenges. The co-invention projects are designed to offer the students ample opportunities for knowledge creation and innovative thinking. During the projects, the student teams jointly create and build knowledge through processes of collaborative designing and collaborative inquiry into challenging phenomena, by means of scientific and other experiments. Successful co-invention processes, and creating knowledge through them, require the teams to collaboratively identify the design problems related to the task, determine constraints around the possible solutions, and actively engage in and take responsibility for the process (Lawson, 2004; Paavola & Hakkarainen, 2014; Sawyer, 2006; Scardamalia & Bereiter, 2014a). In addition, co-invention processes rely on teachers who, in close collaboration with one another, coordinate the processes and provide appropriate facilitation, guidance, and real-time support for the student teams (e.g., Linn, 2006).

Collaborative design is an essential aspect of the invention and making processes. Co-invention processes involve using traditional and digital fabrication technologies for inventing, designing, and making complex artifacts and thus bring elements of the maker culture (see e.g., Anderson, 2012) to Finnish schools. In accordance with the Learning through Collaborative Designing (LCD) model (Seitamaa-Hakkarainen & Hakkarainen, 2001; see also Seitamaa-Hakkarainen, Viilo, & Hakkarainen, 2010), we construe co-design as communal efforts to create artifacts by solving complex and ill-defined problems through iterative processes, in which design ideas are elaborated and refined through analysis, evaluation, deliberation, sketching, prototyping, and making. The importance of participating in embodied design activities and working with concrete artifacts in learning has been emphasized by many researchers (Blikstein, 2013; Kafai, 1996; Kangas, Seitamaa-Hakkarainen, & Hakkarainen, 2013; Kolodner, 2002). Making is an effective way of engaging students in a design mode (Bereiter & Scardamalia, 2003) that guides them to focus on the usefulness and adequacy of ideas and, moreover, to invest efforts in the continuous improvement of ideas. Artifact-mediated knowledge creation is an emergent and nonlinear process, wherein the actual goals, objects, stages, digital instruments, or end results cannot be pre-determined and the flow of creative activity cannot be rigidly scripted (Scardamalia & Bereiter, 2014b). Inventions can be designed only through repeated iterative efforts at solving complex problems, overcoming obstacles and repeated failures, obtaining peer and expert feedback, trying again, and ending up with outcomes that may not have been anticipated in the beginning. In this paper, our aim is to describe this complex and iterative process of collaborative inventing by investigating idea generation, the evolvement of design ideas, and the role of design artifacts in idea generation.

Co-invention relies on the concept of knowledge-creating learning, which, beyond knowledge acquisition and social participation, involves systematic collaborative efforts in creating and advancing shared epistemic objects by externalizing ideas and constructing various types of intangible and tangible artifacts (see e.g., Paavola, Lipponen, & Hakkarainen, 2004; Scardamalia & Bereiter, 2014). Previous studies of knowledge creation processes suggest that advanced collaboration requires group members to focus on a shared object that they jointly construct (Barron, 2003; Hennessy & Murphy, 1999; Kangas et al., 2013; Paavola & Hakkarainen, 2014). The knowledge creation process may be seen to be guided and directed by envisioned "epistemic objects" that are incomplete, being constantly further defined and instantiated in a series of successively more refined visualizations, prototypes, and design artifacts (Ewenstein & Whyte, 2009; Knorr-Cetina, 2001). However, these epistemic objects of knowledge are often difficult to describe because of their complex nature. In this paper, we seek to define the team's epistemic object of knowledge though the ideas that the team generates and the design problems presented by the team members during the co-invention process.

To that end, the aims, in this paper, are to analyze and describe: 1) how the design ideas evolved from preliminary design ideas to the final ideas, 2) the role of the design artifacts in the ideation process, and 3) what kind of a shared epistemic object of knowledge the student team created during the process. This case study of one student team is a preliminary study, through which we seek to build a methodological framework that can be applied to co-invention processes at a more general level. In the following paragraphs, we first present the co-invention project held at the Aurinkolahti basic school, our research aims, and the research data collected. Then we discuss the methods of data analysis and present our results. Finally, we consider the significance of the findings and the possible future development and applications of the methods tested in this study.

Co-invention project at Aurinkolahti basic school

The present investigators organized a co-invention project with the Aurinkolahti basic school in spring 2017. All of the Grade 7 classes, 70 students in total, aged 13 to 14, participated in the project. The Finnish curriculum for basic education involves compulsory weekly craft lessons until Grade 7. Integrated design and making activities, which are characteristic of Finnish craft education, provide ample opportunities for bringing together STEAM subjects. This enabled us to implement learning-by-making projects as a part of regular curricular activity. For assistance, teachers relied on collegial (co-teaching) resources to negotiate emerging challenges: we engaged two craft subject teachers and three other subject teachers (science, ICT, and visual arts) to coordinate the project. Further, we engaged Grade 8 students to function as "digital technology" tutors to provide additional guidance to the student participants. The Innokas Network[1] offered support regarding digital instruments, materials, and coding initially to the tutor students, who provided peer support to the participating students, and when necessary also to the inventor teams. The teachers were familiarized with the technologies used, as well as given pedagogical support.

The co-invention challenge, co-configured between teachers and researchers, was open-ended: "Invent a smart product or a smart garment by relying on traditional and digital fabrication technologies, such as GoGo Board[2], other programmable devices, or 3D CAD." Before the project, the Grade 8 tutor students arranged a GoGo Board workshop for every participating class, so as to familiarize the students with the possibilities and infrastructure of the GoGo Board and to promote the emergence of ideas on how programmable devices could be utilized in the inventions (cf. Ching & Kafai, 2008). The GoGo Board is an open-source hardware device, developed at the MIT Media Lab, for prototyping, educational robotics, scientific experiments, and environmental sensing (Sipitakiat, Blikstein, & Cavallo, 2004). The actual co-invention project was initiated in February, with a two-hour ideation session, arranged in collaboration with the Finnish Association of Design Learning. During this session, the students self-organized into teams and put forward the preliminary ideas of their inventions. The project involved eight to nine weekly co-design sessions (two to three hours per session) during March, April, and May 2017. The teams also presented their co-inventions at two Co4-Lab events, held at the University of Helsinki.

Research aims and data

This paper focuses on one of the teams that was followed and video recorded during the project. The team consisted of four boys (Markus, Oliver, Leo, and Joel), aged either 13 or 14. They invented the "MGG" ("Mobile Gaming Grip"), a pair of handles that improve the ergonomic use of a mobile phone while playing games. The team worked through the whole process in intensive, self-driven collaboration, all members being highly engaged. They demonstrated high motivation to participate in the project and appeared to enjoy the design process and its epistemic challenges. The team went through a two-stage process, first building a concrete prototype from basic materials, i.e., wood, rubber, and masking tape (see Figures 1 and 2), and then creating 3D CAD models based on that first prototype.

Taking our cues from the ethnographic video data, we formulated three partially interlinked research questions:

1. How did the design ideas evolve from preliminary ideas to the final ideas?
2. What was the role of the design artifacts in the ideation process?
3. What kind of shared epistemic object of knowledge did the student team create during the process?

The video recordings were made using a GoPro action camcorder, placed on a floor-standing tripod, and a separate wireless lavalier microphone. The camera was positioned at a high side angle to capture the team's actions as fully as possible. The first author was also present during every co-design session and made observations and field notes to support in-depth analysis of the data. The video data consisted of nine recorded session, totaling 13 hours and 15 minutes of recordings. The methods used to analyze the video data are explained in the following two sections, together with the results of the analysis.

Figure 1. Prototype of the MGG (Mobile Gaming Grip).

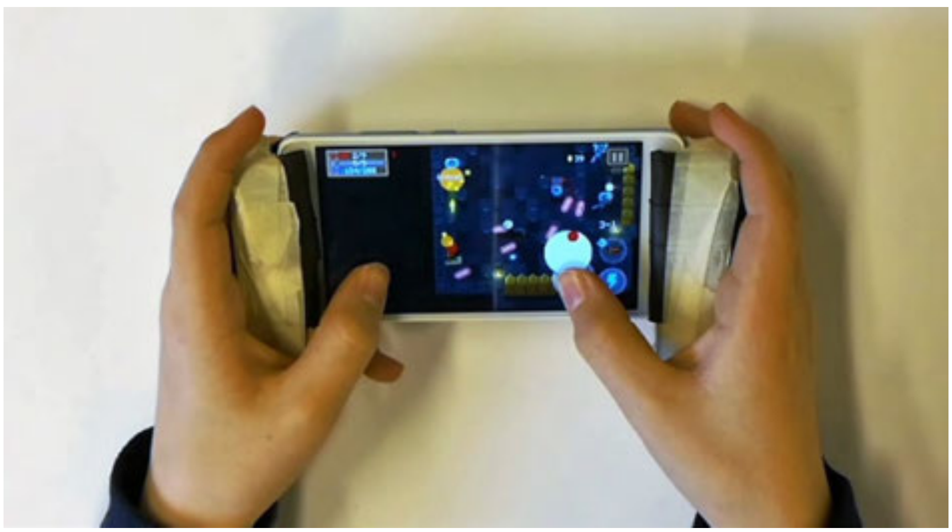

Figure 2. MGG prototype in use.

Evolvement of design ideas and the role of the concrete artifacts in ideation

We analyzed the evolvement of the design ideas by systematically picking out from the video data all ideas that the team generated. The analysis was conducted using the ELAN multimedia annotator (version 5.2). We used an expression of a design idea as an analysis unit. For every idea, we determined the following factors:

- Possible preliminary parent ideas or a theme to which the idea related.
- Whether the idea was included in the final design, i.e., was a final design idea.
- Whether the idea was artifact-mediated.

To gain insight into the role of design artifacts in the ideation process, we formulated three categories of artifact-mediated ideation: 1) the student is looking at a design artifact while generating the idea; 2) the student is holding a design artifact while generating the idea; 3) the student is holding and looking at a design artifact, and pointing to or modifying it while generating the idea. During the analysis, the second category was removed, as it did not occur in the data. Based on the analysis, a network graph of the design ideas and their evolvement (Figure 3) was generated using the Cytoscape[3] network visualizing software (version 3.6.0).

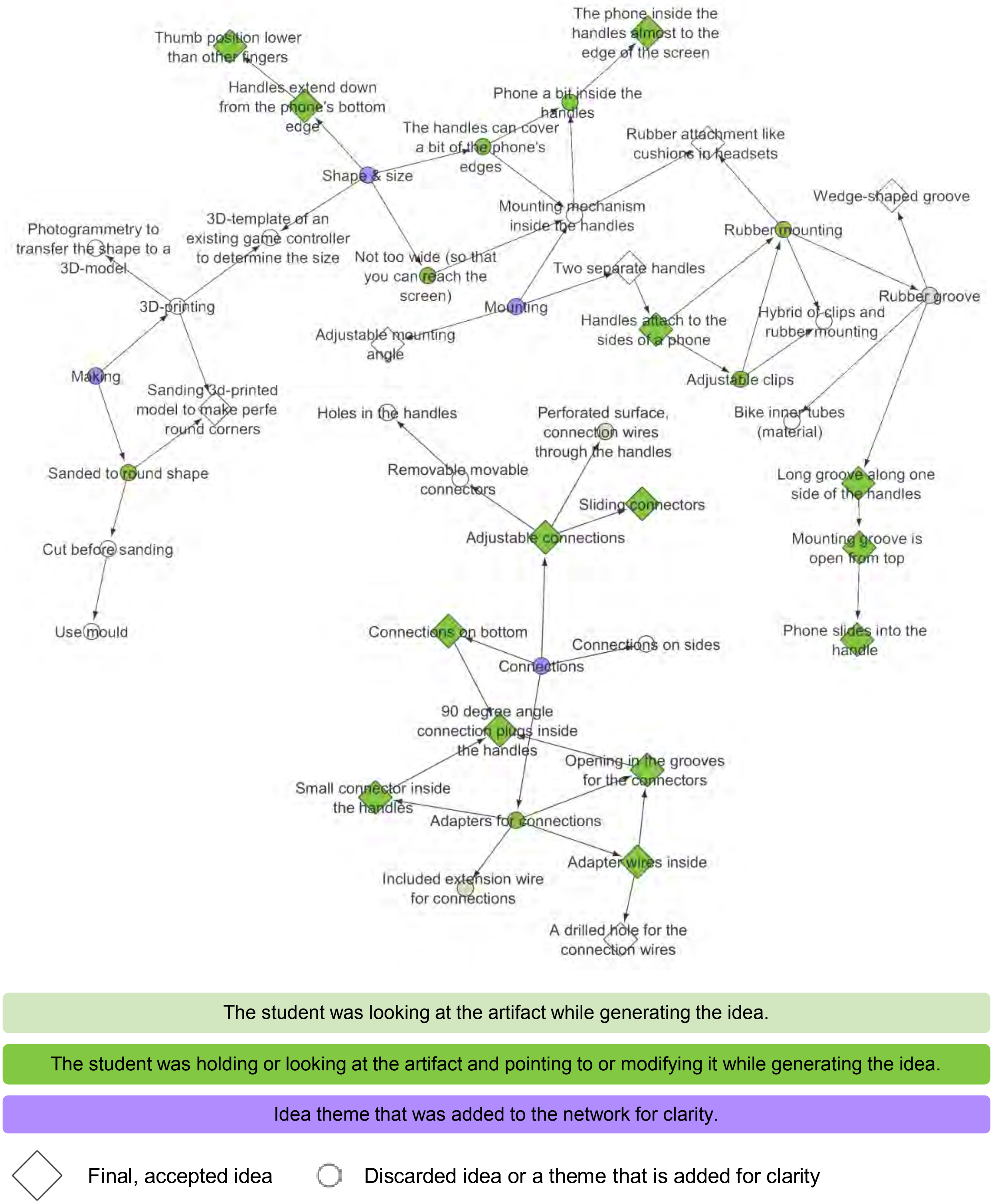

Figure 3: Network of the evolvement of design ideas and the role of design artifacts in it.

The visualized network of the evolvement of design ideas reveals how the team developed their ideas through an iterative process. The preliminary ideas, such as having two separate handles, using adapters for audio and charger connections, or using 3D printing as a method of making, triggered the impulse to generate more refined design ideas.

The arrows in the network graph represent the direction of the ideation process, leading from preceding parent ideas to new ideas. Some of the parent ideas were combined in the ideation process, and some were rejected when new ideas emerged. The idea network also demonstrates the large number of individual ideas that were incorporated into the final invention.

The role of artifacts in idea generation also emerges from the visualization of idea development (Figure 3). The green color identifies the ideas that were generated while the team members were focusing their attention on the artifacts. More than half of the ideas were artifact-mediated, and in most cases the artifact was the center of attention, being tinkered with or modified while the idea emerged. An even larger proportion of the ideas that were incorporated in the final invention were artifact-mediated.

Describing the team's shared epistemic object of knowledge

The close collaboration within the team, as well as the democratic nature of their teamwork and decision making, indicated that the team members clearly shared the same epistemic target object during the whole process of active development (see Riikonen, Seitamaa-Hakkarainen, & Hakkarainen, 2018; cf. Engeström, 1992; Paavola & Hakkarainen, 2014; Seitamaa-Hakkarainen & Hakkarainen, 2001). During the idea evolvement analysis, it became evident that the network of ideas in itself reveals more profound and wider concepts of knowledge than just themes of design ideas.

However, the network of ideas does not reveal the whole nature of the team's epistemic object of knowledge. It provides the answers to the design problems, but the complexity of the design problems and the knowledge work required to solve these remain hidden. To describe the team's epistemic object through the themes around which the team created knowledge during the project, a second round of video data analysis was conducted. In this round, we isolated the expressions of design problems and the conversations preceding the ideas and analyzed them by methods of qualitative content analysis. This enabled a model of the team's epistemic object of knowledge to be constructed (Figure 4). The model consists of four interlinked themes that the team considered and developed during the process, within the uniting theme of mobile gaming. We next present our observations of the interlinked nature of the four themes and the complexity and sophistication of the epistemic challenges that the team faced, drawing on samples of the discussions among the team.

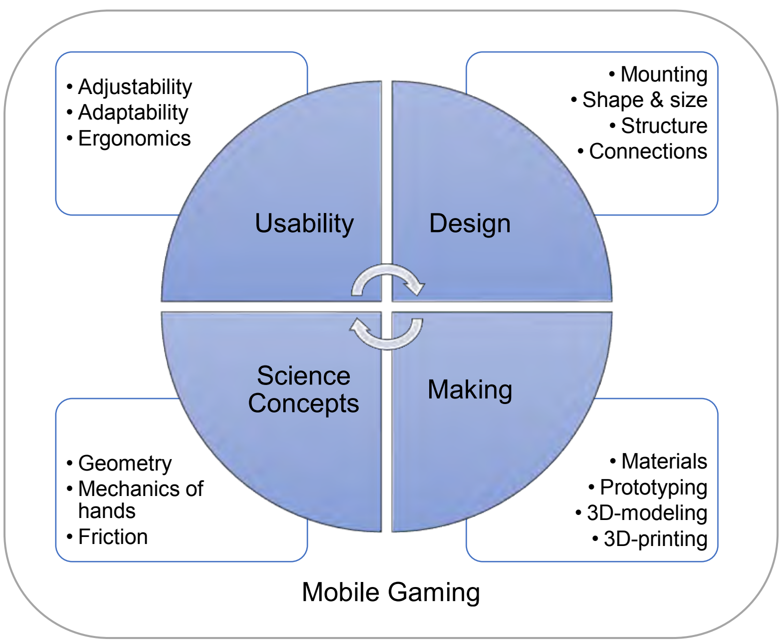

Figure 4: Model of the MGG team's epistemic object of knowledge.

The following conversation demonstrates the intertwined nature of the concepts that formed the team's epistemic object, as well as the versatility of thinking that was required from the team during the co-invention process. The conversation triggered the determination of the size of the handles on the basis of considerations of usability and the mechanics of hands. During the conversation, the team also defined two design constraints: the target group for whom the handles are meant and the space that has to hold the mounting mechanism that attaches the handles to a mobile phone. Setting these constraints established the foundation for more refined knowledge work and ideation.

> *Oliver: We should think about the size... if it were here like this* [gestures to others to demonstrate the size and shape], *could you still reach the screen easily enough?*
>
> *Others: Yes, maybe.*
>
> *Oliver: So, then it should be about like this* [draws a shape around his phone].
>
> *Joel: It's not usual to have something important in the middle of the screen. Although in Geometry Dash there is that practice thing there.*
>
> *Oliver: I don't know if that matters. Who plays Geometry Dash with these anyway? I think that these are more like for driving games and for FPS games that you can't play conveniently on a mobile phone.*
>
> *Oliver: Now, if it's like this, we have this much space for the things that will hold the handles in place. So, we need something like...*

In co-invention processes, the support provided by teachers to the teams is essential (cf. Linn, 2006). However, owing to the complex and unforeseen nature of the design problems, the teacher often becomes a member of the team, providing expertise to the team but unable to provide definite, pre-determined solutions. The teacher must engage in knowledge creation with the team, thereby democratizing the relationship between the teacher and students. The following sample demonstrates the role of the teacher in ideation as an expert member of the team. The conversation further reveals how an artifact, a hearing protector headset, which was unrelated to the theme of the co-invention, acted as an inspiration source for the rubber mounting system of the handles. The teacher's expertise then enabled the idea to be transferred into a practical design solution. From the viewpoint of knowledge building, this sample is also interesting, because during the conversation a science concept, friction, became incorporated into the co-invention process. This conversation took place between one team member and the teacher. Other team members were present during the conversation and took part in it at a later stage.

> *Oliver: We thought we would do something like this. We need something that, you know, holds the handles in place. We think it could be something like this, that the phone fits into, and it holds the phone in place.* [Demonstrates the idea by inserting the phone between the ear cushions of a hearing protector headset, see Figure 5]
>
> *Teacher: Yes…*
>
> *Oliver: But we don't know how to make it yet.*
>
> *Teacher: It could be rubber… some sort of grooves. We could try to make those from a bike inner tube or something like that. Like, if you push the phone in, friction holds it in place. Could it be wedge-shaped?*

Figure 5: A team member tinkering with his phone and a hearing protector headset.

During the co-invention process, the team was able to identify design problems and use them to direct their process. The following conversation demonstrates one such incident. In addition, it demonstrates how concrete artifacts help to define design problems. Furthermore, this conversation highlights how the team posed epistemic challenges to themselves. The team could have decided to design the handles for one phone model only as an easy solution to the problem, but they decided instead to seek an adjustable solution.

Oliver: The problem is that this [the audio plug] can be in different positions. The charger connector is always in the center on Android devices, but this audio connector is a problem. I don't know if we should make such handles that you cannot use the audio connector in all mobile phones.

Joel: In my phone the audio connector is here.

Markus: And on my phone, it's on the bottom.

Oliver: So, it's a problem. Phones have the connector in different spots. […] Could we make the connection adjustable? So that it slides or something like that...

The team also innovatively strove to combine traditional making by hand and new digital technologies. For example, in the next conversation they ideated how they could create a 3D model using a concrete handmade artifact and photogrammetry.

Joel: I think it would be fun if we could take lots of pictures and create it [the 3D model] from those. You know, make the shape using modeling clay, then take a lot of pictures of it and transfer that to a 3D shape and then edit it.

We also observed theoretical scientific concepts emerging as a result of knowledge creation. This final conversation sample shows how a theoretical mathematical concept surfaced through the knowledge creation. Before the conversation, the team had already made the prototype of one of the handles, but now they had to solve how to make the second one so that it would be symmetrical with the first. In this case, the theoretical mathematical concept was the formation of a round shape when the number of sides of a polyhedron approaches infinity.

Markus: Can I sand this?

Oliver: Yes…or wait! We can't begin to sand it to a round shape now because we do not know how we can then make those symmetrical.

Oliver: If we first, you know, begin to remove like corner pieces from it and gradually make it rounder and then finally sand it to the round shape, then it won't differ so much from the other one.

Discussion

In this paper, we aimed to analyze and describe 1) how design ideas evolved from preliminary ideas to the final ideas, 2) the role of concrete design artifacts in the ideation process, and 3) what kind of a shared epistemic object of knowledge the student team created during the process. This case study of one student team is a preliminary study, through which we seek to construct a methodological framework that can be applied to co-invention processes at a more general level. In this discussion, we appraise the results obtained and reflect on how to further improve and deepen the analysis.

The visualized network of idea evolvement (Figure 3) reveals the multifaceted and iterative nature of the team's idea generation process. Ideas were being generated, analyzed, and thus accepted or rejected during the ideation process. Furthermore, the ideas evolved through an iterative process of combining and modifying design ideas. Although the team's co-invention in itself may seem simple, creating it required a significant amount of innovative thinking and solving of complex design problems. Coming up with the final design ideas took several stages of ideation around multiple themes. The number of individual design ideas that formed the final invention was astonishing and signifies further the large quantity of epistemic efforts required to create the invention. The role of the design artifacts in the ideation process suggests that artifacts have an important role in stimulating ideation and knowledge creation (cf. Ewenstein & Whyte, 2009; Knorr-Cetina, 2001). In particular, the often artifact-mediated nature of the ideas that were incorporated into the final design raises interesting questions regarding the significance of artifacts and concrete making when ideas are being refined and developed.

The team's epistemic object of knowledge began to surface from the network of idea evolvement. When combined with the expressions of design problems and the conversations preceding the ideas, we were able to form a model of the epistemic object as a framework of four interlinked concepts, within the context of the theme of mobile gaming (Figure 4). It is interesting how versatile and sophisticated were the concepts of knowledge that the team had to handle, ranging from concrete making to theoretical scientific concepts. Being able to form a model of the epistemic object helps us to consider what kind of learning takes place during co-invention processes. The fact that the team took on epistemic challenges beyond what was required or absolutely necessary is a significant finding in itself.

Overall, we believe that the analysis methods used in this investigation were successful and provided interesting and rich results. To gain further insight into the ideation processes and the roles of design artifacts therein, it may be beneficial to incorporate investigation of the roles of individual team members into the analysis. Our aim, in the future, is to further develop this methodological framework and apply it to larger video data, with a view to obtaining results that are more generalizable.

Endnotes

1 The Innokas Network is a collaboration of forward-looking schools, universities, and companies focusing on children who are learning 21st-century knowledge and skills. Innokas aims to find ways to make creativity, innovation, and technology part of everyday schoolwork. Innokas's thinking is based on the Innovative School concept, in which the school and its surroundings are seen as a holistic network of learning environments improved by technology. The Innokas Network is coordinated by the Department of Teacher Education, University of Helsinki, by the City of Espoo, and by six sub-coordinators from Finland. Since 2011, over 40,000 students, teachers, parents, learning technology companies, and other stakeholders all over Finland have participated in our network activities. More information about the Innokas Network is available at https://www.innokas.fi/en/.

2 http://gogoboard.org/

3 http://www.cytoscape.org

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Acknowledgments

Academy of Finland grant 286837 (Co^4-Lab) and Strategic Research Council grant 312527 (Growing Mind)

The Boundaries of Knowledge Society to Prepare Teachers in Iran

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Abstract
In line with the Knowledge Building goal of re-creating schools as knowledge creating organizations, the purpose of the present paper was to investigate the required infrastructure to facilitate the transformation of the education system in Iran to a knowledge creation organization. We also aim to explore the limitations and the challenges to reach this goal,and provide ideas for developing and expanding the boundaries of the teacher's knowledge society. By adopting concepts such as the community of practice, expansive learning, and knowledge creation organizations, the researchers suggested the concept of the expansive knowledge society to provide the opportunity in which the practitioners and agents of the teaching's community expand to the extent of the local society. We believe that through establishing the expansive knowledge society, interaction between the teachers and the society will be increased, resulting in sharing of knowledge, meaning, and idea among teachers and other agents in the society. This may facilitate the transformation of schools to a knowledge creation organization.
Keywords: Knowledge Society, Knowledge Sharing, knowledge creation organizations, Society, Community of Practice

Interaction

Scardamalia (2002) and Scardamalia and Bereiter (2006) presented 12 principles that altogether describe Knowledge Building as a principle-based pedagogy that are set forth to make knowledge creation more accessible to teachers and students. These 12 principles frame Knowledge Building as an idea-centered pedagogy with students as epistemic agents, creating knowledge through engaging in complex socio-cognitive interactions. As Bereiter and Scardamalia (2014) explain, "Knowledge Building" in the learning sciences (Scardamalia & Bereiter, 1991; Scardamalia, Bereiter, & Lamon, 1994) and "knowledge creation" in the organizational sciences (Nonaka, 1991; Nonaka & Takeuchi, 1995) are synonyms, each entered into the literature at about the same time and enjoying currency in different contexts. It is only in the last decade that they have come to be understood as synonyms, however. Learning science research is conducted largely in schools with participants spanning pre-school to tertiary education. Organizational research is conducted largely in out-of-school contexts with adults. Knowledge creating organizations can appear in many shapes and sizes — such as scientific think tanks, commercial design labs, a team of entrepreneurs, a network of software engineers, an artist collective, a community of Civil War historians. From knowledge building perspective, today's education system needs to be redesigned as a "knowledge creation organization", in order to foster design thinking among today's learners (Bereiter & scardamalia, 2006). Such a change cannot be simply scripted by researchers and handed over to teachers and students; rather, it requires adaptive knowledge process and participatory structures (Zhang, 2012). The purpose of this study is to examine what the required infrastructure is in order to transform education system in Iran to a knowledge creation organization.

Literature review

A review of the literature shows that universities play a vital role in facilitating creation of knowledge creation organizations in societies. Universities react to changes in society and manage their processes through the creation of knowledge (Rowley, 2000). The relation between universities and the society is not a new issue; it has been a subject of research in higher education for a long time. To explain the relationship between universities and the society, several theoretical approaches have been proposed in recent decades, such as new model of production (Gibbons, et al, 1994), triple helix of university-industry-government (Etzkowitz & Leydesdorf, 1998), Actor-network theory (Latour, 1987), post-normal science (Funtowicz & Ravetz, 1993), post-academic science (Ziman, 1996). All these approaches emphasize the universities' accountabilities for the society, and highlight the importance of a dialogue between universities and the society in order to create a network whose aim is knowledge production. Gibbons, Limoges, Nowtony, Schwaertzman, Scott and Trow (1994) stated that knowledge is always influenced by the dimension of continuous negotiation to cover the interests of various actors (p. 4). Nowotny, Scott & Gibbons (2001) suggested that the one-way link between universities and the society needs to change to a two-way and mutual interaction, involving dialogue between universities and the society which ultimately results in the formation of a new public field called "Agora[1]"—a concept which is similar to the notion of knowledge creation organizations. Habermass (1971, 1986) stated that universities must be able to establish solid links with the society and become a public space (Khaniki, 2017, Farasatkhah, 2016). In fact, universities' functions are not limited to academia, but also include the society. Therefore, the university must enter dialogue with the society (Khaniki, 2017). Farasatkhah (2016) stated that there are two models in the explanation of knowledge in universities: the first is the linear model that refers to the one-way promotion and transfer of knowledge. The second model recognizes knowledge as a social and cultural affair, a stream of communication and semantic networks in the society and culture (p. 96-97)

The site of knowledge production is shifting away from merely universities to include universities and non-university locations (Gibbons & et al., 1994, p. 6). In fact, co-construction of Knowledge is made by both universities and non-universities (Farasatkhah, 2016, p. 149). In this way, the local society becomes a stakeholder, establishing a stewardship for knowledge. As such, academic training cannot be separated from the social and environmental context in which it takes place, as this separation will determine the extent of knowledge society in the local society.
Within the context of the relationship between universities and the society in Iran, many studies have shown that academia is not interrelated with the society. Such lack of relation between the universities and the society has resulted in ineffectiveness activities and raised criticisms (Kazemipour, 1991; Ghanei Rad, 2002; Rafeipour, 2004; Chalapi & Memar, 2005; Mohammadi, 2007). Also, many academic scientists in Iran have expressed concerns about a gap between 'university-society' and 'academics people-citizens' in the current era (Fazeli, 2017 & Farasatkhah, 2018). In this paper, we examine how universities and the society can collaborate to form a knowledge creation organization, which may facilitate the formation of knowledge creation organizations in schools.

Methods

A qualitative methodology was used in this study in two sections. The first section was done by using semi-structured interviews. The goal of the interviews was to probe the viewpoint of the participants to provide insight into the the relation between universities and the society in order to facilitate the formation of a knowledge creation organization which may help to transform schools to knowledge creation organizations. The thematic analysis was applied to analyze the data. In the second section, the conceptual analysis in a model of conceptual development was used to create a concept and defence of it (Short, 1991).

Results

Phase one: the result of interview

We noticed three main themes in data that offer an entry point into the relation between university, knowledge and society

1. relation between universities and the society:

The participants believe a need to a mutual relation between universities and the society, as they mentioned "the university is a result of civic dynamism … is a living.". "the society create the university to get a help in its social developing.". They emphasized that it would not be a one-side relation but "there is a screw twist on it". Also, the knowledge will build through these "dialectic and two-side relation" between society and universities". So, the knowledge is "social contrast and will build socially."

2. the existing challenges in this relation:

The main challenge which they mentioned was the control of the government over the universities and the society. "In Iran, universities were built due to the plan of governmental modernising", as "it was not an organic and natural relation … to view the issues of society … to form the suitable language and concept to see and talk with the society." Also, they believe that the teacher education in Iran did not train the teachers to have a social responsibility; "they trained expert teacher in a shape of labour force for a government not the society…"

3. the strategies to overcome the challenges

[1] A public space in which science is confronted with society and the public, in which all people are conversant with science.

To overcome the challenges, they stated that we need “action”. “we need to come back to actions and actors.” The action would not be restricted to universities, “we should open the university gates to the society.” Forming “Dialogue” between actors in universities and in the society would make a two-side relation as we expected. “being in society and talking with it not only for exchanging words but meanings, ideas, values, norms…”. In these regards, the triangle of teacher education -chair, professor and student- will have actions in society and have interactions with it. “we need organic teachers who have organic relations with society and local society… volunteering and informal relation with various social institutes like parliaments, city councils, NGOs, … to construct their knowledge.”

Phase two: conceptualizing the expansive knowledge society

Expanding the boundaries of knowledge society of teachers

In this paper, we propose removing the boundaries between the education systems (teachers in this paper), and the society with its all aspects as social, economic, cultural aspects. Farasatkhah (2018) stated that the teacher education university should be granted a degree of freedom and independence in order to establish a mutually interactive relationship with the city. In other words, he suggested that the teacher education system should be more closed to the government and be more opened to the society. At the same conference, Talkhabi (2018) pointed out student teachers not only need a conceptual and a lesson-based knowledge but also require the acquisition of a living and being a teacher, which will only be realized through the interaction with the society.

We propose the concept of Expansive knowledge society, as everyone in the CoP of teacher should be engaged in the instructional program in the society as part of their routine work. The key concept of Expansive knowledge society derived from the Community of Practice (CoP) and theory of the expansive learning. In the view of expansive knowledge society, we extend this community beyond the formal teacher society, which means extending that to the local society in order to create a knowledge creation organization. Individuals in such a knowledge creation organization work together to generate new ideas and knowledge, which ultimately contribute to the formation of a knowledge creation organization in the education system. By expanding knowledge society of teacher and creating a knowledge creation organization, we hope to extend the boundaries of knowledge society of teacher, then mobilizing the knowledge sharing between the teachers and a greater community (i.e. the society).

Engestrom (2007) alluded to what Adler and Hecksher (2006) called ‘collaborative community’ or ‘collaborative interdependence’. They listed four challenges that this emerging third type of community must meet; less fixed boundaries and more capable of being bridged and merged than in traditional communities, high level of technical division of labor and diversity of knowledge and skills, authority-based knowledge and expertise and bring values into the realm of public discussion (Adler & Heckscher, 2006, p. 44).

Knowledge building is at the heart of Carl Bereiter and Marlene Scrdamalia’s ideas. In fact, Bereiter and Scardamalia considered participating in a discourse of knowledge building as the most fundamental event of education (Talkhabi, 2018: 151). Based on what Bereiter and scardamalia state, we consider the discourse to build and share the knowledge as an educational effort which should be made in the knowledge creation organization. From their points of view, the goal of creating knowledge is the production of knowledge which has social value. All participants in the creation of knowledge have the right to participate in common social goals. Expertly opinions have been distributed among and within the communities. The path to knowledge movement is such that the groups access the knowledge through the involvement in the common effort (Talkhabi, 2018: 92).

Individuals of knowledge society and knowledge creation organizations participate in particular cultural activities over time, develop their understanding of who they are and what they know about their communities and their goals. These communities can be a group of university students, teachers, professionals, academic professors and school staff. Throughout the knowledge society and knowledge creation organizations, teachers will have real partnerships as members of the community and will exchange their ideas and meanings with other actors. and knowledge creation organization of teachers should not be restricted to formal actors in education, even the actors of the wider knowledge society, the society, must enter this organization.

The local face-to-face groups in the participating communities were not only involved in changing their local activity system. In this paper, we believe that the agents in local activity systems should take part in a broader activity system and discuss and refine their idea and meaning in education with them. According to Engeström (2010), each activity system has exactly one object which defines the activity system through motivating structure and action within the activity system. Within an organization such as a company, and also within sub organizations such as work teams or departments, there are, typically, a number of different objects motivating structure and action, so that a number of activity systems can be examined. Different activity systems within an organization influence or hinder one another. Support the transformation of several activity systems into a common activity system leads to create a common knowledge between activity systems in accordance with the values of the community. So, this strategy will lead to create the greater knowledge society for teachers. Lave and Wenger (1991) claimed that in this sense "understanding and experience are continuous and mutually constructive" (p. 51).

Teachers knowledge sharing in an activity system within a school is a common form of knowledge society of teachers. But knowledge society will not be ended to this activity system. The activity system of school will build the two-dimensional, interactive, and dialectical communication with the upper knowledge society. The local society is a larger activity system that encompasses the activity system of school. Teachers should act as academic citizens to exchange knowledge and meaning with social actors and agents and create a knowledge creation organization. Bereiter and Scardamalia noted that the work in a knowledge society with a pedagogical approach requires the explanation of knowledge in two completely different ways. First, knowledge is what people earn and become part of their existence. And knowledge is what people work with and become part of their lives (Talkhabi, 2018: 107). From this perspective, the knowledge society of teachers needs to communicate with the upper knowledge society and create a knowledge creation organization (local society and greater society). Communication in these communities is not hierarchical. Rather, Wenger (1998) refers to a network of complex and mutual relationships between interns and other members. Therefore, each member of the community of practice must be able to express opinions, attitudes, and views about professional activities and actions, and criticize and reflect on them by other members of the community of practice. The mutual interaction causes individuals to correct, refine and re-evaluate their knowledge and experiences. This situation leads all agents in the society to cultivate a deep personal and professional respect to the educational systems and caring their actions in systems and producing the similarity in norms of commitment, mutual care, and concern.

Ideas for expansive community of practice of teachers and creating a knowledge creation organization

1. Groups of teachers should involve in different activities and events at different areas in the society. For instance, exactly in the time we are writing the paper, the annual international book exhibition is holding in Tehran. The book always reminds us a symbol of the school, but there is not any particular place for teachers in this exhibition. We consider this exhibition as a useful opportunity to expand the communities of practice of the teachers. The space and chat rooms provide an opportunity for teachers to talk not merely with their students and school parents, but also with those beyond their schools' walls, to talk with past, current, and future students. On the other hand, it will be an opportunity for citizens to share their ideas and opinions with the community of teachers in different roles and positions.

2. Another example is the presence of public education in the context of large-scale societies like streets and public places. Recently, Tehran has offered online reading opportunities (a manuscript of online books from famous writers) in the metro (subway). If our goal is to mobilize the teachers beyond the school and their knowledge society, the presence of teachers in a truly teacher's meaning that is, the type of work should not be considered as part-time or private job in this type of program is necessary.

3. Creation of the education parks, with a presence of the educators and parents and whoever want to attend. the education parks are a situation in which the agents in teaching society will discourse face-to-face with the agents within the society, and they can both redefine and review up-to-date approaches and methods in education.

4. In Iran, people are interested in the religious and cultural celebrations. Most of these ceremonies are held in the mosques and local society. To expand the knowledge society of teachers, the teachers should present and enter these ceremonies. In this regard, it is suggested that some of these ceremonies be held in the schools and hosted by the teachers and students to allow citizens to enter the school space and to remove somewhat the distance walls.

Discussion

As we have argued in this article, the chances of success are enhanced when a balance is sustained in the relationships between the agents of the knowledge society in the university and the knowledge society in the local society. We believe that it will occur through the mutual knowledge sharing by the expansive knowledge society model and creating a knowledge creation organization. The teachers should become a social teacher, then he/she must understand the mission in front of society and the society. In other words, the teacher should be a society and city teacher, not just a teacher of the neighborhood or a school. For this reason, the interaction must happen to share their knowledge, meaning, and ideas with the society and get their ideas and meanings. Openness, responsiveness and demonstrated relevance on the part of both organizations build trust and confidence between the educational systems and local society. To realize this goal, knowledge society of teachers should not be limited to within schools and between schools. It should extend to the society, history, culture and city to create a knowledge creation organization. As Engström & Sannino (2010) pointed out, the smaller activity systems, school, should be expanded and coordinated with their more comprehensive activity system, the society, while, the current universities in Iran are separated and bordered from the society. If the borders removed, the academics will return to the original source of it, the city and the society.

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Creating cultural and epistemic carryovers for sustaining idea-centric practices: A Principal's Contribution.

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Abstract

This paper attempts to explain the role that a principal plays and the impact he/she has on instructional practices. The case study describes the rationale and strategies put in place by the principal in a government-aided secondary school in sustaining different innovative practices such as knowledge building pedagogy and technology in Humanities department; inquiry-based learning in the mother-tongue department and Design Thinking in Science department over the years. The case study adopts an interpretive approach to understand the principal's contribution in creating two particular carryovers in sustaining idea-centric classroom practices. We positioned these carryovers as strategic mechanisms that coordinate school activities and encourage teachers' behaviour, moving their school towards the kind of commitment envisioned by leaders. The two types of carryover explored in this case study is cultural carryover and epistemic carryover. We acknowledged the limitation of a case study for generalisation purpose, but we considered the case study useful to understand the ways in which a school leader demonstrates some exemplary practices associated with commonly identified instructional leadership. In the concluding section of the paper, we discussed the emerging themes when these two carryovers working in tandem in deepening our understanding of a principal's role in the journey of transforming classroom practice.

Introduction

A Principal has a substantial influence on what happens in a classroom by emphasising and encouraging certain connections across policies, practice, and research (Wahlstrom & Louis, 2008). This paper attempts to explain a principal's impact on the instructional practices in the classroom. This paper adopts an interpretive approach to the role that a principal plays to understand two particular carryovers (Toh, Y., Jamaludin, A., & Hung) that the principal has created to support and sustain idea-centric classroom practices in the Humanities Department. We positioned these carryovers as strategic mechanisms that coordinate school activities and encourage teachers' behaviour, moving their school towards the kind of commitment envisioned by leaders. The two carry-over effects emphasised here are cultural carry-overs and epistemic carry-overs. Culture factors refer to an extensive set of constructs such as beliefs, moral values, traditions, language, and rules of behaviour in a community. Cultural carryover thus refers to 'soft' structures that can create ripples of these factors over time and space within a community, e.g. emphasis on risk-taking, the kind of interactions encouraged in the environment. Epistemic beliefs are beliefs about knowledge and how we acquire knowledge. These beliefs have a significant implication on the processes of learning, self-regulation and achievement for the teachers as well as the students. Epistemic carryover, in this case, refers to the nature of classroom discourse, nature of assessment, types of learning artefacts, inquiry framework. We see a parallel cultural to the principle of collective cognitive responsibility which describes the ability of each member of the community to practice agency of their learning and the knowledge advancement of the community; and the epistemic carryover to the principles of epistemic agency that sees all members of the community owning and co-creating the vision and the work involved. (Scardamalia, 2002). Thus the study is of value to knowledge community on two points, one, the approach to sustain the practice in relation to other similar practices embraced by other departments in school; also the layering of how knowledge building principles in instructional leadership.

Research Question

How can a principal contribute to creating cultural and epistemic carryovers to transform classroom practice towards idea-centric practice?

Background and Need

There has always been an emphasis on instruction leadership in the development of principals. Some examples are OECD' school leadership model, Beatriz, et al,, 2008; Principal Quality Practice Guideline in Alberta, 2009; Leadership Growth Model of Singapore as explained in Jayapragas, 2016). This is especially so as we move closer into the 21st century teaching and learning, leadership practices that foster "deep learning" (Hung, et al., 2004) has taken root in research on leadership, tackling the issues of the many conflicting priorities a principal faced on a daily basis while playing their instructional leadership role.

The conflicting priorities got more complex in the backdrop of the rapid technology development and how the technology is changing every form of interaction outside the school. In which education policies are expected to respond to the demand from parents, society and industries. This, in turn, gives rise to new expectations towards schools. These new expectations tend to come with contradictions and flux. Therein lies the challenge to principals having to make decisions about daily operational matters and big-picture instructional and professional matter. Creative leadership is what is perceived to be essential for a principal of 21st century, being able to see and do things differently to improve the lives of students (Stoll and Temperley, 2009)

Aligned to the idea of 'creative leadership', Toh, Y., Jamaludin, A., & Hung (2012) proposed the idea of 'ecological leadership' and attempted to identify four different sustaining effects from an ecological perspective. These components are socio-cultural carryover, infrastructure carryover, economics carryover, and epistemic carryover. They explained carryover as strategic mechanisms that coordinate school activities and encourage teachers' behaviour, moving their school towards the kind of commitment envisioned by leaders. Each carryover relates to different strategies; different target problem needs and creates outcomes. Research has shown the effort that focused on putting in place infrastructure and technology soon see these turning into an expensive gadget and more so, soon find the investment hard to sustain. These phenomena are aligned to development of learning sciences relating to cultural and epistemology study. These two carryovers are deemed to be able to create more long-lasting on transformational practice.

To reconcile the multiple demands on principals, the myriad of decisions principals have to make on a daily basis, and more so to support their response to the flux created by trends of technology, deep learning, 21CC and media literacies (just to name a few), there is an urgency to unpack abstract concept such as creative leadership and ecological leadership towards sets of prioritisations and levers that are both principled and workable.

Methods

In this study, we collated the principal's participation in three weekly professional learning community meetings (each an hour long), two term-end research meeting (each 2 hours long), and an interview (1.5 hours). The data collated includes the principal's (i) vision of an idea-centric classroom, (ii) his role, (iii) the plan and strategies he put in place to bring about such transformed classroom practice, (iv) his take on aligning school practice to research to policies initiatives. We analysed the data according to the two construct of epistemic and cultural carryovers and organised it in Table 1 below. We specifically focus on the way principal's employ the strategies to sustain idea-centric classroom through a multitude of macro and micro-actions to generate a common purpose and effect of innovative practice in the school. We invited the principal to provide further input to the tabulation. This triangulation with the principal is essential to create a dynamic and practical analysis of these two carryover effects together and more so, the cross-over between these two effects.

Limitations & Delimitations

In this study, the process of the school selection followed the criteria largely based researcher's current collaboration with the school on knowledge building research over the past years. The researcher used the knowledge building research as the criteria for defining "idea-centric" and "innovative" practice. However, it is clear that in this study, an idea-centric practice meant that students were learning and developing important 21st-century competencies. Due to the previous collaboration on knowledge building practice, this study tends to be more of an "appreciative inquiry" (Cooperrider, D. L., & Whitney, D) where we looked specifically into what worked well in the context under study.

The strength of this study in balancing these limitations is the fact that the researcher has spent substantial time working with the principal and teachers of the school. The nature of collaboration being design-based research means that the researcher has worked closely with various stakeholders in school and understand the school well.

Analysis
The analysis unpacks two level of interpretation, the values and the strategies, of the principal on knowledge building practice. The first part described how he mad sense of knowledge building based on his understanding and his observation. He then has to set the bigger picture, i.e. drawing explicit connections of the value of knowledge building to the overarching values of the school.

Identifying unique values of knowledge building practice:
The principal perceived the value of knowledge building practice in a very favorable light. He shared how he observed that the weaker class participated more actively when they are engaged in a knowledge building way. He acknowledged the difference that knowledge building made to his students. He also articulated the alignment of the knowledge building innovation to what the school is trying to do; specifically, as a way to make “assessment for learning” (a common term in MOE, Singapore) happen in class, and “for teachers to instil critical thinking and metacognition in students”. He explained his school vision in developing ‘future ready’ students. To be“ future ready ” means to be collaborative, to have 21st-century competencies (21CC) such as critical thinking and to achieve this, he felt that the way to shape teachers’ thinking and interpretation of it is of foremost importance. Knowledge building practice seemed to be able to foster this symmetry of a “thinking pedagogy” and a “thinking student” in class.

In analysing his contributions at various meetings, we derived how he was drawing connections on how the value of knowledge building complements the values of the school and more importantly allows the value of schools to be explicated and manifested:

- The principal perceived the value of knowledge building work as going beyond content knowledge. He noted how knowledge building has a “coherent place” within the multiple school programs and concerning the directions of the whole school in the following way.
- Knowledge building work builds in students “the attitude” they need to develop curiosity and resilience which is aligned to the core curricular work in school. These values are also integral to what the school is trying to do on all levels as expressed in the school motto, RISE, which reminds students of the importance of “resilience, integrity, synergy and excellence”.
- Throughout our interactions, the principal put great emphasis on the schools’ values. He described how the school emphasised the total development of students in areas of social, emotional, moral, leadership, cognitive, aesthetics and physical. Thus it was vital for him to see and to articulate the complementary nation of Knowledge Building practice and the school vision of teaching and learning.
- Teachers: how the school perceived every teacher as a CCE teacher, beyond academic achievement. Thus, teachers doing KB work in class are also building these values
- Assessment: The principal also noted that the shift in the regarding national examinations as shifting toward higher level thinking skills. The principal was also interested to more fully utilise the technological affordances of KB. For example, considering what the“ next steps of KB ”might be, such as providing a“ report card ”for students to know where their thinking is.

Table 1. summarising findings of analysis and principal's perspective in various aspects of the cultural and epistemic carryovers:

Factor	**Descriptions of factor**	**Principal's interpretation of these factors and extending it into carryover effect**	**Strategies (Policy-Practice-Research) to create the carry-over effect over time, over space, over actors.**
Cultural factors	Sets of belief in classroom practice.	Pedagogical practices must bring about the joy of learning and fulfil the learning needs of students. For example, graduate students in the last lap of their national exams preparations will need to feel empowered and geared towards applying their conceptual understanding to tackle the exam questions. In the midst of going through this, they also must still satisfy their curiosity and derive meaning and purpose in their learning. For assessment, it is also linked to the pedagogical practices of using good questions to deepen learning about content and engage students in thinking. So being able to ask questions about what they learned is as important as being able to explain what is needed.	Acknowledgement of the difference that KB practice made to, specifically the weaker class concerning the students' participation in class. This reveals a focus on (i) 21CC; (ii) potential and possibilities with weaker classes. Continuous conversations amongst School Management Committee members (comprising of vice-principals, heads of department, staff developer, Snr teachers) and staff to enable a mindset shift that academic grades must not be over-emphasised and become the single over-riding focus. That developing 21CC and infusing joy of learning are just as critical to developing students to be future-ready learners, in close alignment to school's vision of developing future-ready learners. School's Curriculum Development & Innovation Committee set up to focus on the use of quality questioning amongst teachers (2019) to ask students to identify, explain or demonstrate what they know. The teachers can then identify gaps, misinformation & misuse of knowledge.
	Values	The values that undergird the school approach to different matters, it includes: The approach to unexpected or unintended consequences e.g. drops in exam results due to change of mode of engagement.	Constant dialogue and emphasis lead by school leaders to work towards a better shared understanding and a progressive shift of mindset from an over-emphasis on academic grades and more on building 21CC and intrinsic motivation of students. Committed mentoring and apprenticing structure where the trail-blazers impacts and spreads his/her influence on another or a few teachers in his/her department so that the innovative pedagogical

		Inherent coherence in meaning and purpose of learning anchored on developing the metacognitions in students and building our school's RISE (Resilience Integrity Synergy Excellence) values through the process of learning	practice can continue. It is always this adage – people come and go but once the structures are firmly put in place, will stand the test of time to enable the continued practice because the critical and tacit knowledge & expertise has been passed down.
	Traditions	What is archived and recorded to sustain the tradition, e.g. heritage corner. Respecting and creating "tradition" through open-door policy for school leaders, encouraging open conversations where ground-up initiatives are welcomed to ignite and sparked-off creativity and innovations.	Provide support, i.e., infrastructure, structures, processes to enable initiative to thrive and be sustainable. Build a generative learning community (professional learning community for every subject) so that such pervasiveness will help to generate more possibilities for other departments to take part.
	Language	Common language to elicit understanding so that all staff will be on the same page when we talk about developing future-ready learners even though infusion of joy of learning will have some varying differences across departments, depending on the anchor pedagogical practices each department has, for example, inquiry for Science, Problem based Learning for Mother Tongue languages, KB for History and Music, Design Thinking Protocol for Design&Technology department.	The consistency of language across all department action plan to articulate the approach and strategies to be adopted for innovative pedagogical practices.
	Rules of behaviour,	Emphasis on risk-taking.	Principal participating in weekly professional learning meeting. School management commitment took the first plunge on Knowledge Forum.
	Interactions : leaders - middle managers – teachers – students	Developing Future-Ready Learners (School Vision), Joy of Learning & Entrepreneurial Dare undergirding the drive towards innovative pedagogical practices.	Beyond school community: Scaling up across schools and Scaling out to other schools is instrumental to entrenching deeper into a strong practice, further igniting the passion and joy of teaching for our fellow fraternity members and joy of learning for our students.

Epistemic factors	The kind process of learning	the role of epistemic perspective in school leaders, middle managers, teachers' decision making	Consistency in the articulation of learning intention relating to values and belief of classroom practice through mission, vision, policy alignment.
	Knowledge	Critical and tacit knowledge & expertise passed down	Accord continued resources, e.g., protected space & time for generative conversations and collaborations to take place. Prepared to facilitate and enable my teachers to go to other communities of practice to spread their knowledge and help other schools in their implementation.
	Self-regulation	Make refinements to steer the course of action such that the plans will unfold & lead to the desired outcome. Supportive structure of professional learning community.	Frequencies, platforms, opportunities to reflect by all members of the community. Continue to preserve protected time for our teachers as reflective practitioners to consolidate their learning and improve their professional practices in their respective professional learning community. Leverage on existing structures to weave in pedagogical scaffolds and under pedagogical practices in Singapore Teaching Practice, to put forth the relevant resources that can be used concerning the teaching processes and areas.
	Achievement	Redefine notion of success such that it cannot be based solely on academic grades. The joy of Learning and acquisition of 21 CC dispositions and competencies are just as critical.	Supporting the KB report card initiatives: Challenge notion of achievement by initiating the use of learning analytics to surface evidence of the development of 21CC.

Discussions

The data synthesized from the different data-set and the principal's input and comments to the analysis. We derived three central themes when considering the cultural and epistemic carryovers. The following emerging themes held together well but as discussed in the limitation study, more leaders with such exemplary practices and experiences need to be studied to understand the nuance of their contribution.

Theme 1: Openness and Connectedness:
Principal supported teachers' growth through varied professional development, for example, collaboration in research, writing research papers, sharing at local conferences. As a result, the culture of the school was busy and intense, but purposeful. Principal joined in the subject-based professional learning community on a weekly basis, modelling commitment to such professional discourse and the focus on innovative practice. In so doing, he also showed his understanding about what was going on in the school and community and kept teachers aware of the same by communicating changes and helping to make teachers' work around these innovative practices relatively more convincing.

Theme 2: Committed mentorship and apprenticeship:
The principal is committed to mentorship and apprenticeship among the teachers, providing time, space and structure for mentoring and apprenticeship to happen. Principal's explicit support for teachers to share their expertise and personally took note of these 'peer leadership' in an active way, for example, allowing researchers to study these peer leadership.

Theme 3: Scaling out coupled with scaling up:
Encourage connection to "knowledgeable others" internally and externally (international community). The principal is supportive of school organising network sessions, both for the local and international community. This creates a robust professional development culture within the school.

Theme 4: Principal's knowledge:
Awareness of innovation and research. Principals worked to help their teachers understand technology by creating spaces and opportunities for professional learning, e.g. particular professional development time crafted out of school management meeting for all middle managers to experience the successes of the innovative practice in school.

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Developing Low-Achieving Students' Understanding and Engagement in Productive Discourse through Meta-Talk in Knowledge Building

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Abstract: This study examined how low-achieving students could engage in productive discourse in a designed knowledge building environment emphasizing students' epistemic understanding of discourse through meta-talk. 9th Grade students worked on Knowledge Forum® (KF) collective engaging in inquiry on "what is art and design" in a visual art classroom in Hong Kong. Knowledge-building inquiry was integrated with classroom meta-talk on what constitute good discourse with students examining on their own KF inquiry; a comparison class was included. Qualitative analysis suggested how students' experience in the classroom meta-talk might have influenced their epistemic understanding of discourse and engagement in productive discourse, followed by quantitative analysis indicated that enriched-KB class changed more from fragmented ideas to coherence and connected ideas over time than the regular KB class.

Introduction

It is now increasingly recognized that meaning and knowledge are generated through people's interactions and dialogue when they sharing ideas from different perspectives (Wegerif, 2001). As dialogue, or discourse, is epistemic in nature and central to knowledge development, developing students' productive discourse has become the focus of recent research on learning, specifically in the learning sciences (Sawyer, 2014), and much progress has been made in analyzing and developing students' discourse (van Aalst, 2009; Zhang et al., 2007; 2009). The goal of this paper is to investigate how low-achieving students could engage in productive discourse in a knowledge-building environment emphasizing students' epistemic understanding of discourse through meta-talk, with students talking and inquiring into their own discourse.

Dialogic teaching and classroom discourse

Several recent studies have indicated the importance of dialogue for students' learning, understanding, speaking, and knowledge growth (Alexander, 2008; Behzad & Mohammadi, 2014; Mercer & Littleton, 2007); however, a meaningful discourse does not engage spontaneously, simply by putting students together (Chan, 2001). Chinn, O'Donnell, and Jinks (2000), for example, found students would not engage deep understanding or productive discourse when evaluating the quality of conclusions about electrical circuits unless they were asked to elaborate their ideas and reasons. Thus, a growing body of research has emerged on scaffolding students' dialogic engagement. Mercer and colleagues proposed "exploratory talk" as a way to scaffold students' reasoning and problem-solving for knowledge construction through productive discourse. Exploratory talk involves critically and constructively engaging in a discussion (Wegerif & Mercer, 1997); however, teachers have reported it is difficult to help students engage in a rich dialogue, while students found it difficult to engage in a "critical conversation" by building on each other's ideas to achieve understanding together (Howe & Abedin, 2013).

A "Thinking Together" intervention emphasizing on teaching "social ground rules" had been used to help students engage in a productive dialogue for solving reasoning problems – e.g., "the group takes responsibility for decisions" and "alternatives are discussed before a decision is taken" (Mercer & Littleton, 2007; Wegerif, Mercer, & Dawes, 1999). If the teaching of ground rules can help students engage in a rich dialogic discourse, then a focus on developing epistemic understanding of discourse – i.e., the nature of discourse and inquiry – would be important for examining knowledge advance. It is even more pressing to see whether and how it might help students, especially low-achieving students, engage in high-level inquiry and productive discourse.

Knowledge building and productive discourse

Developing students' productive discourse has always been a central role of knowledge building, and progressive discourse is key to knowledge creation. Dialogic discourse in knowledge building goes beyond interaction classroom dialogue on meaning making, and focuses on knowledge advances. Knowledge building emphasizes the students' collective responsibility-taking to advance community knowledge through sustained idea improvement (Scardamalia & Bereiter, 2014). Students worked collaboratively on Knowledge Forum® (KF) to create and advance new knowledge through sustained idea improvement. While many researches on knowledge-building model and pedagogy have focused on developing students' knowledge-building inquiry and discourse (Chen, Scardamalia, & Bereiter, 2015; van Aalst & Troung, 2011; Zhang et al., 2009), there have been relatively few studies on scaffolding students' understanding of why and how discourse is important, and in turn, how engaging in productive discourse by their understanding enhancement on discourse itself. As the capacity to engage in discourse is particularly important for low-achieving students, how to link online and offline discourse needs to be investigated.

Similar as epistemic criteria used by scientists and students to justify scientific models (Pluta, Chinn, & Duncan, 2011), knowledge-building principles can be considered as epistemic standards for advancing discourse. Scardamalia (2002) proposed twelve knowledge-building principles to guide knowledge-building practice that can be seen as epistemic criteria for students to develop their understanding of discourse. While academic interest in examining knowledge building and its positive effects on students' learning from different perspectives is growing (Lee, Chan, & van Aalst, 2006; Lin & Chan, 2018; Zhao & Chan, 2014), few studies have investigated how KB design can help low-achieving students' learning and engagement in productive discourse engagement. Yang, van Aalst, Chan, and Tian (2016) provided some evidence for the positive effects of KB for low achievers, but the dynamics of students' classroom talk and understanding of principles have not been systematically investigated.

Similar as "accountable talk" which emphasizes accountability to the community, knowledge, and accepted standards of reasoning (Michaels, O'Connor, & Resnick, 2008) in developing academic productive talk, "knowledge building talk" (KB Talk), is an important feature in KB classrooms focused on idea improvement and knowledge creation. While KB talk is included in different studies in general terms, there has been no systematic analysis of it, nor of how teacher systematically help students understanding principles for developing a deeper epistemic understanding of discourse. Moreover, no studies have involved comparison classes, or attempted to show whether different degrees of emphasis on classroom and meta-talk with KB principles would result in different levels of discourse understanding and engagement. Productive discourse engagement through classroom meta-talk, defined as "discourse about progress and difficulties in the main knowledge-creating effort" (Bereiter & Scardamalia, 2014, p.46) in the KB community needs to be investigated.

Accordingly, this study examines the design of a KB environment focusing on low-achieving students' epistemic understanding of discourse development through classroom meta-talk to help them engage in productive discourse. Specifically, the goal is to examine how the classroom dynamics that brought about students' productive discourse, both online and offline.

Methods

Design the knowledge building environment for productive discourse

In this study, both the enriched-KB class and regular KB class addressed the same major topic on Arts and the difference is a key emphasis on classroom talk in the enriched KB class.

Specifically, the design of the enriched KB class design emphasized on scaffolding students' principle-based understanding of discourse, through explicit reflection to support student' productive discourse engagement (Figure 1). The detailed design for the enriched-KB class was as follows:

(1) Cultivating a KB classroom culture for discourse (Figure 2). To help students engage in collaborative work and make their ideas public, they worked in groups to design an artifact. The teacher then prepared "colored scaffolds cards" labeled with KB scaffolds (e.g. "I need to understand", "my theory"), on which students wrote questions or ideas before post them on the KB Wall.

These cards presented a kind of talk that enabled students to generate ideas, revise theories, build on others' ideas, and create knowledge in their community by using strings to connect the build-on relationships (Figure 3). This drawing and visualizing of ideas was an essential scaffold for low-achievement students, who often had difficulty illustrating their understanding. While both classes designed artefacts, and used a KB Wall, the teacher in the enriched KB class also regularly conducted KB Talk to help students reflect on what they had learned and how their ideas had developed. Students could thus identify promising ideas from their KB Wall and KB Talk, and continue their lines of inquiry in KF.

(2) Starting and developing progressive inquiry in KF by identifying good KF notes (Figure 4 & Figure 5). Students continued their inquiries from the KB Wall to KF, using embedded KF scaffolds to develop their

ideas. Students were also asked to identify good notes from their KF progressive discussion, and explain what made these notes good ones.

(3) Scaffolding understanding of discourse and deepening productive discourse moves with KF discourse reflection and KB principles discussion (Figure 6). First, we regularly provided students with ATK and SNA to students assessment results to help them reflect on understand their contribution to the community. Further, similar to how they engaged in KB Talk in their group work and KB Wall work at the beginning of the semester, students also regularly engaged in classroom KB meta-talk, intertwined with their KF work, and monitored their online KF work by reviewing what they had discussed, identifying other questions that needed need to be inquired into, comparing the difference between their discussion and other class's discussion, and reflecting on their online discourse using knowledge-building principles (Figure 7). Both groups of students used the KB Wall and KF inquiry, however, the teacher in the enriched-KB class also used extensive KB meta-talk to help students develop deeper discourse understanding and regularly reflect on their discourse work.

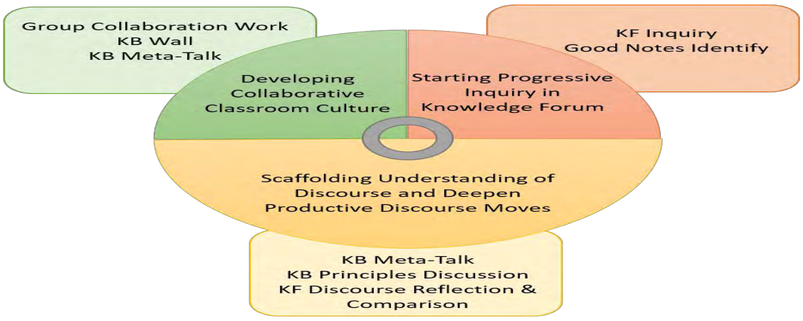


Figure 1. Pedagogical Design


Figure 2. An example of group mind map and student "colored scaffold cards" work

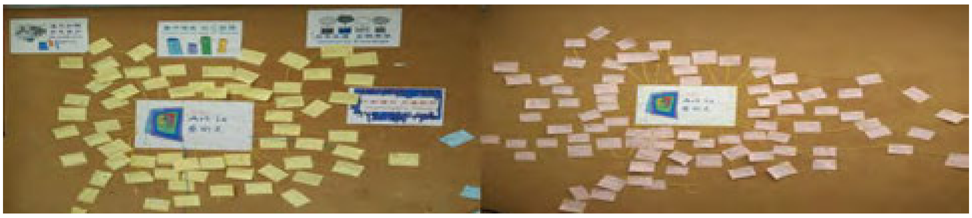


Figure 3. An example of KB Wall

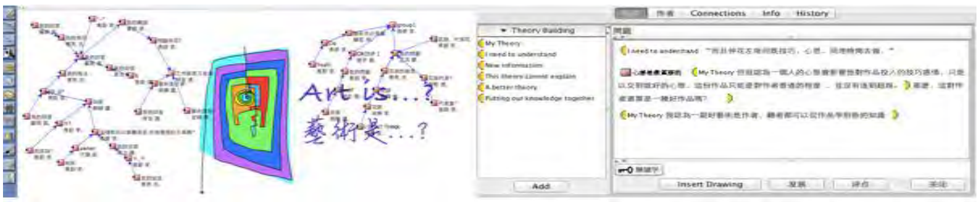


Figure 4. An example of KF view and note


Figure 5. An example of students' work on KF

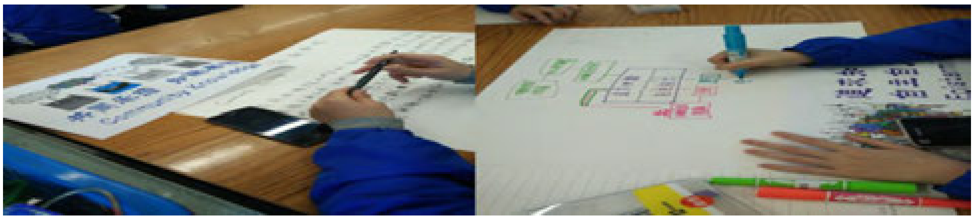


Figure 6. An example of explicit reflection with KB principles

Figure 7. An example of classroom KB meta-talk on principles discussion

Data sources

This study utilized multiple sources of data including students' classroom discourse, designed artefacts, written test on discourse understanding and KF engagement.

(a). Classroom discourse and artefacts: we video-taped all of the classroom discourse, and also collected the artefacts students designed in the classroom.

(b). Epistemic understanding of discourse: students were asked to work on a written test with the question, "what do you think is a good inquiry and discourse?" at the beginning and end of the semester.

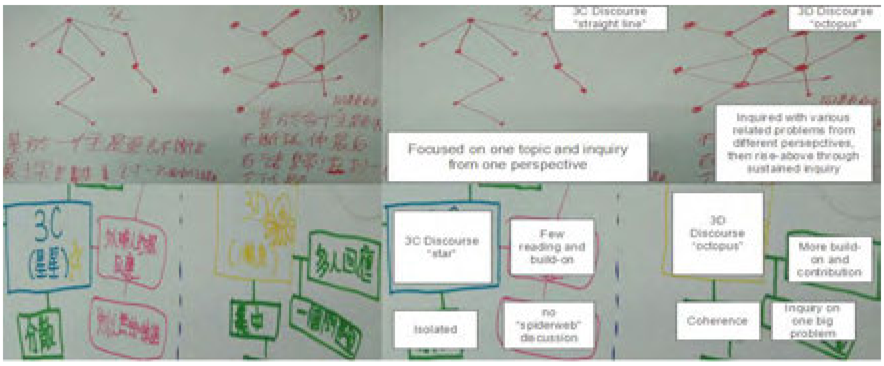
(c). Knowledge Forum engagement: students' KF work was quantitatively analyzed by KBDeX.

Analysis and Findings

Classroom meta-talk for productive discourse engagement

The first research question examined how the students engage in classroom KB meta-talk in developing their discourse understanding and productive discourse. KB meta-talk was conducted regularly and the following two examples of a classroom KB meta-talk with students talking and inquiring into their discourse.

Example 1.



In this example, the students explained the difference between their own and another class KF notes structures: using a diagram. In their writing (see translation), they created terms such as "octopus" versus "straight line", the "star" versus "the spiderweb" to represent the different ways in which ideas were developed; moreover, students also explained the reasons (e.g. "few reading and build-on") and suggested how the class can move forward "if everyone in our class participate...generate questions and build on" pointing to the notion of community knowledge.

After the drawing, the teacher engaged students in meta-talk to explore the differences further. The meta-talk involved S1 proposing that the shape in their class is due to its single-question focus. S2 built on this idea saying their responses directly followed the previous one; to which S1 replied:

> In the beginning, our initial idea had four build-on notes, but later, our build-on notes become a line and one followed another directly. However, the other class had two build-on notes for the initial note, then later, had another two build-on notes to respond to the above different notes, and *continued to rise-above for inquiry*. Later, a new question was generated. In our case, we only had one question - all the build-on notes responded to this question directly, and *we did not inquire further.*

The example suggests how the teacher used meta-talk to develop ways to work with low-achieving students, with students creating artefacts using diagram and analogies (e.g., “octopus”, “spiderweb”). Students’ drawings were followed by more discussion, to engage their deeper thinking about discourse structures. These examples points to how talking about their KF talk, helped them reflect on their inquiry and on ways of improving their discourse (“If everyone in our class…”)

Example 2.

Table 1: Classroom meta-talk on discourse understanding

Agent	Classroom meta-talk transcripts
Part One	
T	What did you learn from our previous KB lessons? What is your idea on a good discussion?
S1	We need to have an initial goal and *inquiry further*.
T	Any other ideas?
S2	I think we need to have *diverse ideas* and inquire from different perspective.
S3	As well, *collective responsibility*, as what we are doing now, we listened to other students’ ideas, then we had a community discussion and inquired into the question.
S1	We are learning how to discuss and *build knowledge*, What we learn is a thinking approach, it refers to discussing with other people to inquire into a question and build knowledge, and *putting knowledge together*. As well, to inquiry further does not mean only discuss the question, but need to *rise-above to improve ideas*.
T	Any comments on S1’s idea?
S6	Continue to inquiry further based on one point.
Part Two	
S1	We can also apply what we learned about thinking models in arts *to different contexts*.
T	As S1 said, we emphasized… not thinking in a direct way, but thinking and discussing from various perspectives. *So my question is how can we use this model to learn visual arts*?
S7	We also need to *find information to support*, for instance, searching on the Internet, and *integrating that information into our ideas*, then later, present ideas to our classmates and discussing with them together.
S8	We can share our questions and ideas, which help us *generate new questions and improve ideas* for further inquiry.

In the part one, the teacher started a meta-talk by explicitly asking students to reflect on their understanding of the nature of good discourse. S1 proposed an initial idea that a good discussion needed to have a goal followed by further inquiry. As in KF inquiry, the teacher invited students to build-on to S1’s idea, S2 build on that discussion needed diverse ideas, and the need to inquiry from different perspectives, after which S3 that build on including the “*collective responsibility…*” linking the principle to their current experience “as what we are doing now”. For low-achieving students, it seemed particularly important for students to reflect their experiences as they worked on the principles. Later, S1 started to reflect on their progress pointing to the importance of “putting knowledge together…” In the part two of the meta-talk, the teacher tried to help students situate their discourse understanding in relation to the subjects of visual art. Different students contributed (S7 and S8) suggesting their developing understanding of idea improvement and continuing inquiry.

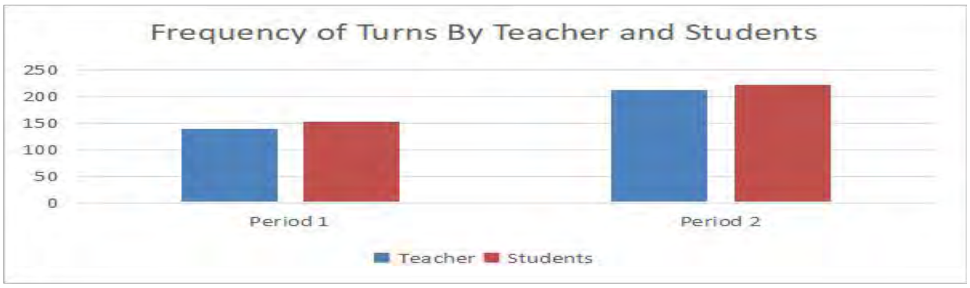


Figure 8. Frequency of turns by teacher and students in the classroom talk

Additionally, we calculated the turns by teacher and students in the classroom talk. Figure 8 illustrated that the frequency of turns between teacher and students were almost equally in a knowledge building classroom while teacher often dominate the classroom dialogue in the traditional learning classroom. More importantly, it also showed that students took the agency to engage in classroom talk both in period 1 (week 1 to week 7) and period 2 (week 8 to week 16). In period 1, the teacher tried to develop a collaborative classroom culture with various group work and presentation, followed by KF work. In period 2, more classroom talk especially the meta-talk was conducted to reflect on students' KF work by developing their understanding of discourse through knowledge building principles discussion and KF work comparison explicitly.

Was classroom meta-talk effective on students' discourse understanding?

Qualitative analysis of students' discourse understanding responses based on the lens of knowledge building principles and different patterns emerged ranging from simple to more sophisticated views of discourse corresponding to the KB principles (Table 2). For example, students thought good discourse was more about "participating in the discussion…need to have a good topic to discuss" in the pretest; but they saw discourse as more about "improving ideas…summarizing what we had discussed and putting our ideas together…" in the posttest.

Table2. An example of students' epistemic understanding of discourse

Written question – "what do you think is a good discourse?"	
Response Level	Students' response on discourse understanding
1	"…***Participate*** in the discussion…have ***a good topic*** to discuss…"
2	"…***achieve an agreement*** in the end…and our ***problem will be solved*** after the discussion…"
3	"…***improve our*** ideas…***summarizing*** what we had discussed and ***putting our ideas together***, then continue the discussion to achieve an idea or ***understanding in the communit***y…"

Students' KB discourse engagement in KF

We used Knowledge Building Discourse Explorer (KBDeX) (Oshima, Oshima, & Matsuzawa, 2012) to examine student contribution of ideas and connectedness through keywords network change over time, and analyses were included for both classes. Specifically, using KBDeX, we examined the keywords network change over time. As Figure 8 shown, the keywords network changed from Phase 1 (Notes 1 to 13), to Phase 2 (Notes 1 to 50) to Phase 3 (Notes 1 to 100). Compared with the enriched-KB group, the regular KB group's keywords network was more fragmented, with isolated small cultures and notes. This suggested students in the enriched-KB group integrated their discussion ideas more consistently than the regular-KB class.

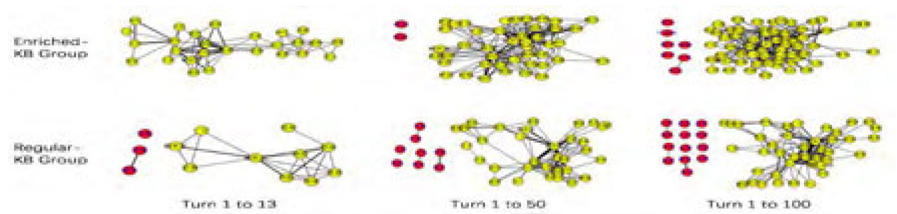


Figure 9. Keywords network change over time between enriched and regular KB group

Summary and Conclusions

This study has examined how the development of productive online and classroom discourse supported low-achieving students' KB work by scaffolding their epistemic understanding of discourse through classroom meta-talk. We designed a KB environment that focused on meta-talk, with students engaging in "discourse about their discourse" and linking their online KF work with their classroom discourse. Such a design is particularly important for low-achieving students. We characterized students' epistemic understanding of discourse by identifying differences in their general sense of what constituted good interaction in a discussion; collaborative problem solving with answers; and responses alluding to the knowledge-building notion of deepening inquiry and idea improvement. Classroom discourse suggests how low-achieving students can be engaged in meta-talk about their KF discourse, supported by creating artefacts/diagrams to represent their understanding of discourse; engaging in explicit reflection linking their experience with principles; and talking about KB principles in relation to their own KB work. KBDeX analyses suggest the enriched KB class changed more from fragmented ideas to connected ideas than did the regular KB class. This study has design implications, in that it supports the key role of progressive discourse in knowledge building and proposes ways of promoting productive discourse by enhancing students' epistemic understanding of discourse and engaging in meta-talk. As there is little extant research on knowledge-building among low-achievers, this study is important because it illuminates how such students can develop productive discourse through KB meta-talk explicitly by engaging in discourse about their discourse.

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Fostering Student Voice and Epistemic Agency through Knowledge Building

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Abstract: One of the central goals of a classroom teacher is to foster student ownership over learning. Knowledge Building represents a principle-based approach to harnessing student voice to inform classroom practices, and in turn, foster students' epistemic agency for not only individual learning, but also collective learning. Student voice, thus, is critical to the intellectual life of a KB classroom. This paper explores how Pieter weaves student voice into the fabric of the everyday activities of his classroom. More specifically, Pieter reflects on how he has evolved his KB practices over the years to build student rapport while promoting student engagement and epistemic agency. Together, he and his students co-create classroom norms of interaction, develop shared success criteria, deconstruct the KB principles, and reflect on their collective learning journey. This paper concludes with a discussion of classroom practices that can help set the conditions for co-creating a Knowledge Building culture.

Introduction

One of the greatest challenges of a classroom teacher is to get all students engaged deeply and meaningfully with their learning. Research shows that providing students with choice and autonomy increases their levels of interest and investment in learning (Patall, Cooper, & Wynn, 2010), and student engagement is strongly related to academic outcomes (Willms, Friesen, & Milton, 2009). Ontario's well-being and equity initiative (2013) uses "student voice" as a metaphor for student engagement and participation. Teachers can encourage student voice by "connecting what's happening in the classroom to real-life experiences outside school... [and] supporting students to shape their learning environment while building skills and abilities and preparing for active citizenship" (p. 1). For Pieter, a secondary teacher in Hamilton, student voice is central to developing a culture of learning in his classroom – a culture in which all students can express authentic thoughts and ideas in a safe and productive way. By prioritizing student voice, Pieter creates an environment where students feel that their ideas are heard and considered as valuable input in any ongoing process. This, in turn, allows students to take ownership of what they are saying, as they work through their own thoughts, emotions, and experiences as part of a collective reflective process. There are many approaches to enhancing student engagement in the classroom. For example, teachers can invite students to express their ideas, participate in decision-making processes, and eventually support them to become co-leaders of their learning, accepting mutual responsibility for planning and assessment processes (Ontario Ministry of Education, 2013).

One important initiative in Ontario's Leading Student Achievement Project (Leithwood, 2017) that targets student engagement is Knowledge Building. Knowledge Building (Scardamalia & Bereiter, 1991; 2014) represents a coherent pedagogical framework for giving students more agency over the learning process. Simply defined, Knowledge Building is "giving students collective [cognitive] responsibility for idea improvement" (Resendes & Dobbie, 2016, p. 16). Facilitated, by a set of 12 principles rather than a set of scripted procedures (see Table 1), the class self-organizes to set collective learning goals, pursue promising areas of study, assess individual and group progress, and plan next steps to advance collective understanding. One of the defining features of a Knowledge Building classroom is that students take ownership of their learning (Scardamalia, 2002). In this sense, the Knowledge Building classroom operates quite differently than traditional classrooms. To further elaborate, Scardamalia (2002) describes three classroom models from Teacher A to Teacher B to Teacher C. In Teacher A's class, cognitive responsibility is withheld from students. The teacher "plan[s] and supervise[s] the schoolwork" (p. 70), and students learn from completing assigned tasks and activities. In Teacher B's class, "the teacher assumes cognitive responsibility, but the students are not expected to do so" (p. 70). The teacher sets short-term and long-term learning goals for students, and students are encouraged to pursue them through assigned tasks and activities. In Teacher C's classroom, however, cognitive responsibility is shared between the teacher AND the students. Teacher C makes "an effort to turn strategic cognitive activity over to the students" (p. 71), so that students view themselves as epistemic agents of the learning process. Teacher C's classroom represents the Knowledge Building classroom. Whereas, Teacher A's and Teacher B's classrooms still exist in many schools today, Teacher C's classroom is a rare find.

Over the course of his teaching career, Pieter has been deliberately improving his practice to become Teacher C to create epistemic agency for his students, for other teachers, and for himself. According to Pieter, *epistemic agency* is the idea that students take ownership of their learning and all the steps involved in the process, including what they want to learn, how they want to learn it, and how they want to share it with others. This creates opportunities for authentic individualized learning to take place in the classroom, with each student making the decisions relating to how far to go, how best to express an idea, and what value is associated with each concept. Through effective peer collaboration, students build new knowledge from the roots of their own vision. This paper explores how Pieter weaves student voice into the fabric of the everyday activities of his classrooms. More specifically, Pieter has identified three pedagogical moves to co-create a Knowledge Building culture with his students. Together, they reflect on their classroom norms, values, relations, and processes.

Co-creating a Knowledge Building Culture

Developing classroom norms and success criteria with students

At the beginning of each school year, Pieter works with his students to co-create a common language for understanding complex concepts and goals. This step is critical for Pieter and his students to work together to move their knowledge forward. Success criteria represent one way to visualize and operationalize the value of the learning process as materialized in an end-product. Thus, success criteria can be thought of as the common scale students use to measure the value or success of a given task or enterprise. This means that students need to develop a common understanding of the range of benchmarks that define that value. Because learning and understanding are subjective experiences, Pieter believes that it is absolutely necessary to work with students to co-create a common understanding of what exactly is being measured and how the measuring is being done. As well, he makes an effort to emphasize to his students that there are different ways to express their thinking, monitor their learning, and integrate feedback to improve their ideas – all of which are valid and legitimate ways to contribute to the collective learning process.

Pieter also encourages his students to see how their ideas fit within the ecosystem of everyone else's ideas in the class. Whenever he has a new concept, new perspective, new pedagogy, or anything that he is wrestling with, Pieter brings those ideas to his students, and together, they discuss, explore, and improve those ideas as a group of equals. Both Pieter and his students are changed by this process. Pieter notices that his students begin to truly take ownership of their learning when they see themselves as authoritative sources and the teacher as their co-collaborator. They start to realize that Pieter is not creating artificial situations that he then pretends to explore with them. Instead, they see that these are real, authentic problems that their teacher is grappling with, and they are invited to grapple with these problems alongside their teacher. Moreover, Pieter gives them credit for their efforts, making it transparent to all that they accomplished their solutions together and move forward together.

Shifting power relations in the classroom to open learning opportunities

Simply building trust and rapport with students is not enough to spark deep learning in the classroom. It took Pieter a few years of continuous introspection, immersing himself in his teaching process, and digging deeper with his practices before he realized the true reason for this is the power struggle that existed in his classrooms. It was his ego, his need for control as the teacher – and even his mental model of what the student-teacher relationship was supposed to look like – that was holding him back from becoming Teacher C. When Pieter came to this realization, he took this problem to his students and asked them for help. What started off as a scary and awkward moment quickly became a liberating and invigorating experience as his students suddenly noticed that they could help this teacher that had clearly demonstrated an authentic eagerness to help them. This power shift sparked a passion in his students when they realized they could teach their teacher. They could help this person in authority and actually change the way their classroom functioned. This shift in student engagement inspired Pieter to give more space for student voice in his classrooms. And once Pieter released that teacher control, things in his classroom started moving along very quickly.

More recently, Pieter has been trying to implement Knowledge Building in all his classrooms. When Pieter first read about the 12 KB principles, he was quite overwhelmed by the wealth of information. He had no idea where to start, how to operationalize the principles, nor how to make any meaningful connections to the curriculum expectations. Once again, Pieter took his problem to his students to figure it out together. One common practice in all his classes is that students are given time to break down the curriculum expectations and develop action verbs to co-create a common understanding of what each expectation means. Since his students had already re-written the curriculum expectations into student-friendly language, they decided to do the same with the 12 KB principles.

Through his involvement with Knowledge Building as part of the LSA project, working with his students became the classroom norm. On several occasions, Pieter was asked to assist other teachers across the province in developing an understanding of KB by sharing his journey with them. Pieter would develop a presentation or an activity and then ask his students for feedback. Eventually, one of his students proposed the idea of letting the students themselves speak directly to the teachers and share what they had to say about Knowledge Building. This led to Pieter and his students opening up their classrooms to educators from other schools and districts, making how-to videos and recording testimonials, and even re-writing the KB principles to offer advice for teachers on how to use them. Taken together, Pieter discovered that the most powerful outcome of these experiences was watching his students continuously evolve their interpretation of the 12 KB principles. Table 1 shows a comparison of definitions from experts (Zhang et. al., 2011), teachers (Tarchi et. al., 2013), and Pieter's students.

Table 1: The 12 KB Principles as defined by experts, teachers, and students.

EXPERTS	TEACHERS	STUDENTS
Real Ideas, Authentic Problems		
Students identify problems that arise from their efforts to understand the world and pursue sustained creative work surrounding them.	Students' ideas and problems of understanding drive knowledge advance-ment and need to be at the heart of classroom interactions.	***This is our class, we will use our voices!*** Teachers need to keep students engaged and using their voices and ideas, or discussions will be dead in the water. We need to know that what we are learning will connect to our lives outside of school.
Improvable Ideas		
Ideas are treated as improvable rather than simply accepted or rejected; students work continuously to improve the explanatory power, coherence, and utility of ideas.	Ideas are improvable. Working to improve idea quality, coherence, and utility brings our work into line with others trying to create a better world.	***Every idea can be improved if we work together.*** This principle creates innovation through the mindset that you can always improve from your mistakes. It also focuses on how everyone has a different strength that they bring to a group and how together you can build off them. An important step is the reflection process after assignments.
Community Knowledge, Collective Responsibility		
All participants are legitimate contributors to community goals and take high-level responsibility for advancing the community's knowledge, not just for their individual learning.	Each student accepts responsibility for what the group as a whole is able to achieve, with focus on generating ideas the whole community will find useful.	***We all support each other to co-create our success.*** Teachers and students must work together to be supportive towards everyone's individualism. All classes should incorporate group activities to create an effective and positive classroom environment centered around trust and respect.

Epistemic Agency		
Students set goals, assess their work, engage in long-range planning, monitor idea coherence, use contrasting ideas to spark and sustain knowledge advancement, and engage in high-level knowledge work normally left to the teacher.	Students learn to take over high-level knowledge work (generating ideas and plans, evaluating results, etc.) usually reserved for teachers.	***This is our class, how and what do we want to learn?*** It teaches you to take initiative in your own learning and see learning in a different way. This is applicable to the real world as it allows you to gain the knowledge and skills that are valuable to you. Teachers can help students take responsibility for their learning by letting students explore why things are important and by encouraging students to think about "so what?".
Idea Diversity		
Knowledge advancement depends on the diversity of ideas, just as the success of an ecosystem depends on biodiversity. To understand an idea is to understand the ideas that surround it, including those that stand in contrast to it.	To create new ideas we have to compare and combine diverse ideas, take risks with ideas, and work through complexity rather than focus primarily on asking questions and finding right answers.	***We have to listen to many voices to find the next step.*** Different opinions and ideas lead to an ultimate collective idea. The best ideas come from multiple ideas, different perspectives. Each person has an idea unique to them that has a critical aspect (creative, active).
Rise Above		
Students work with diverse ideas in complex problem spaces; they transcend trivialities and oversimplifications and work toward more inclusive principles and higher-level formulations of problems.	Students deal with competing ideas by formulating higher-level ideas that capitalize on the strengths and overcome the weakness of the competing ideas.	***There are no best ideas – find the good and use it!*** Develops a depth of understanding by pushing limits through stretch assignments, brainstorming, and innovative problem-solving tactics and experiences. Apply concepts to hands-on activities that are interactive rather than long lessons. Continuous improvement of ideas helps us to prepare for the future.

Democratizing Knowledge		
All participants are empowered as legitimate contributors to the shared goals; all take pride in knowledge advances of the community. Diversity and divisional differences are viewed as strengths rather than as leading to separation along knowledge have/have-not lines.	All members of the community find productive roles and take pride in what the group as a whole is able to achieve.	***We work together and take pride in what we do, create, and achieve.*** Incorporate this by giving students freedom in their learning. They should care about what they are doing and by caring will take pride in their classroom accomplishments. Students should be given the opportunity to work with each other's similarities, differences, strengths, and weaknesses. This can be done by making diverse groups for assignments in the classroom.
Symmetric Knowledge Advancement		
Expertise is distributed within and between communities and team members, with knowledge exchange and co-construction reflecting the understanding that "to give knowledge is to get knowledge."	Advancing the frontiers of knowledge is a civilization-wide effort in which we all participate, helping others returns gains to our own knowledge advancement.	***All people must work together, learn together, and succeed together.*** We all learn together, building on everyone's experiences. We know more now than people did 50 years ago, imagine what we will know 50 years from now!
Concurrent, Embedded, and Transformative Assessment		
Assessment is integral to Knowledge Building and helps to advance knowledge through identifying advances, problems, and gaps as work proceeds.	Assessment is an integral part of our efforts to advance knowledge, with self- and group- assessment part of the Knowledge Building process.	***We help ourselves and others to improve our work, our process, and our thinking.*** Create a welcoming environment where students feel comfortable to give honest feedback and can build relationships based on trust and respect. Reflecting and debrief process is crucial to see if goals were met and if there has been improvement. A variety of one-on-one, small group, and class discussions for more intimate and meaningful feedback.

Knowledge Building Discourse		
Students engage in discursive practices that not only share but trans-form and advance knowledge, with problems progressively identified and addressed and new conceptualizations built.	The discursive practices of the community engage all participants in transforming ideas, with critical analysis and efforts to go deeper highly valued.	***We need to discuss, engage, and challenge each other to dig deeper into our learning.*** Everybody needs to be able to listen, and build on each other's ideas. We need to be able to critically analyze all ideas. Dig to that next level of learning by testing and challenging each other to expand.
Constructive Use of Authoritative Sources		
Participants access and critically evaluate authori-tative sources and other information. They use these sources to support and refine their ideas, not just to find "the answer."	Authoritative sources are valued means for under-standing the state of the art in a field; they are also objects for critical analysis and improvement.	***We will find the people who know more than us, question them, learn from them, and then teach them.*** It is important in the classroom to have time reflect and learn from other classmates. Students don't only learn from their teacher and other experts (online, textbooks, guest speakers) but their peers as well. They must be given time to do this in order to enhance their learning.
Pervasive Knowledge Building		
Knowledge Building is not confined to particular occasions or subjects but pervades mental life – in and out of school and across contexts.	All problems, in and out of school, are occasions for building knowledge.	***Every experience is a learning opportunity.*** Look at everything, both in and beyond the classroom, as a learning opportunity. Teachers need to focus on creating an environment where they and students are able to engage everyone and encourages collaboration between everyone as learners.

Reflecting on collective advances and deciding next steps together

One of Pieter's deepest learnings was making connections between the KB principles and the global competencies (CMEC 2018): critical thinking, innovation/creativity, self-directed learning, collaboration, communication, and citizenship. From his perspective, Knowledge Building is both the umbrella and the end goal, the global competencies are the environment and catalyst, and inquiry-based learning is the vehicle to make it all come together. Through continuous learning and experimentation with his students, he created this model about how these seemingly disparate concepts can all fit together and support each other within Ontario's framework of student achievement and well-being. As part of the collective reflective process, Pieter asked his students to reflect on their individual and group performance on each project completed in class. A key component was making connections to how the KB principles influenced their learning as related to both process and product. The following are excerpts taken from student reflections:

> "[KB] is all about us taking ownership of our own learning. At first I did not understand what this meant. After a couple of projects where we got to design the project to answer our questions and then had to pick the Knowledge Building principles that related to what we were doing it clicked for me that we were making the decisions, not the teacher."

> "The biggest impact of using KB in this class has been how we think about the difference between facts and knowing. I used to think that being able to memorize facts was the only thing that mattered in school. Now I think a lot more about what I understand about the things we learn and how it connects to my life."

Figure 1. Students in a KB circle reflecting on the 12 KB Principles.

> "Idea and concept building is usually not one of my strengths. I am not a very artistic or creative person so it can be difficult to come up with ideas or concepts that would bring a new element or view to the project. With the different Knowledge Building activities we did in class, it gave me the confidence to ask others for their ideas, get feedback on particular ideas, and then test those ideas to make sure they work well. I believe that this process was very effective because it was very open and accepting of the different ideas that my group had and it ended with great results."

> "Another area where our group exceled was the trust we had in each other. All of the Knowledge Building principles can be related to how you create the environment you work in. With a healthy environment, it made all of our group members feel wanted and valued which made us feel comfortable around each other. This resulted in our group's morale being high and everyone feeling valued and appreciated."

As an additional exercise to deepen reflection, Pieter asked his students to rank the overall impact of each KB principle on their learning and organize a discussion near the end of the semester. They collectively decided to re-organize the 12 KB principles into four rise above themes based on four statements they coined as "Toth-isms": 1) There is no such thing as a best idea, 2) Every moment is a teachable moment, 3) Every voice matters, and 4) If you earn it you own it. They then self-organized into small groups to share their thinking before breaking out into individual reflection where they identified their top three KB principles before returning to their groups to explain their rankings. Figure 2 shows the KBP Grid designed by the students with the combined rankings from five different classes over two semesters (118 students in total participated). The top five most impactful KB principles as determined by the students are Epistemic Agency (67 votes), Concurrent, Embedded, and Transformative Assessment (46 votes), Knowledge Building Discourse (35 votes), Rise Above (33 votes), and Community Knowledge, Collective Responsibility (31 votes). Based on these results, it can be seen that the four rise above themes are all relatively important to student learning, with students identifying the themes "If you earn it you own it" (123 votes) and "There is no such thing as a best idea" (90 votes) as most important.

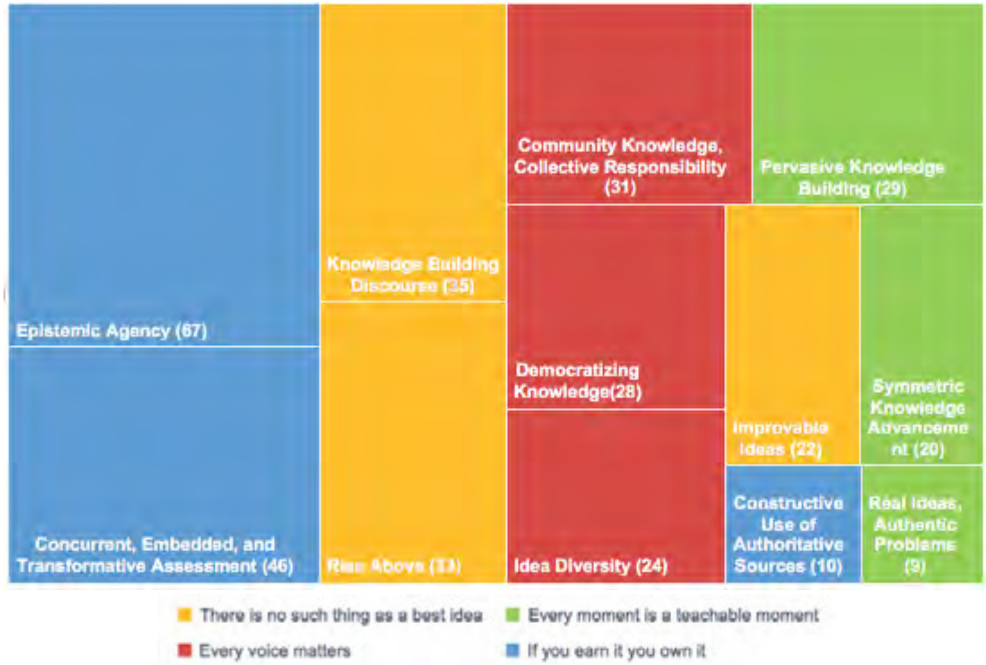

Figure 2. Visualization of student votes on the KBP grid.

Given the amount of variation across student responses in his five classes, Pieter couldn't help but ask them why some principles were being ranked very low relative to others. Pieter wondered if there was a way he could modify the KB process in the future to bring all the principles into balance. Upon further reflection, students came up with several reasons. The ones they ranked lowest, Real Ideas, Authentic Problems and Constructive Use of Authoritative Sources, were the ones that they knew the best. Because these two KB principles had already became a part of their daily lives very early in the semester, they felt they were less impactful overall. They also felt that these two principles, along with Epistemic Agency, represented the basic starting point for any class to build a foundation of trust. From their perspective, many teachers talk about student voice and ownership but rarely follow through. After Pieter had earned their trust, they worked at pushing the boundaries of the student-teacher relationship, and students came to realize that when they took ownership of their learning, they ended up achieving more than they thought they could. However, additional KB principles that they needed to work on were Symmetric Knowledge Advancement and Democratizing Knowledge. Even though students felt it was generally better than the average classroom experience, there were still a few individuals who managed to avoid contributing authentically and equitably to the projects and class discussions. The idea that students were parroting each other and the teacher just to gain favour or have their voices on the record was heatedly discussed. For Pieter, the most fascinating part of this discussion was seeing the authentic nature of these student interactions and the respect they had for one another, even when they passionately disagreed. His next steps will involve working with these last two principles more deeply and helping students find ways in which they can make them an increasingly natural and authentic part of the classroom experience.

Conclusion

While teachers may aim to promote student engagement by inviting students to become active and meaningful contributors of their classroom community, these efforts are not always met with success. Knowledge Building represents one way to activate student voice and foster higher levels of student engagement in the classroom. In a KB classroom, the teacher hands cognitive responsibility over to students so that they can start challenging themselves to go beyond finding the quick and easy answers to digging deeply into concepts, making connections, and building on each other's ideas to create knowledge that reflects all the voices in the community.

In Pieter's classrooms, students felt empowered to take greater ownership of their learning process. Over time, they showed increased confidence in sharing their thoughts, opinions, and questions, in addition to helping their peers reach success together. KB has ignited a passion for learning that they had not previously experienced – learning for the sake of learning and deepening understanding. They are no longer satisfied with simplistic questions that result in simplistic answers – they constantly want to go deeper, reflecting the KB principles of Epistemic Agency, Improvable Ideas, Knowledge Building Discourse, and Rise Above. Past research has shown that promoting student reflections around the 12 Knowledge Building principles enhances student engagement and depth of learning (Lee, Chan, & van Aalst, 2006; van Aalst & Chan, 2007). Furthermore, none of this would be possible without Pieter using student voice to set the initial conditions in his classroom. Pieter showed vulnerability by having honest conversations with his students to develop a sense of mutual trust and psychological safety. Classrooms norms were negotiated, teacher power was extended to students, and ideas were shared freely between everyone. As Pieter illustrates:

> "Once students are exposed to Knowledge Building, how they approach their own learning changes in many ways, some obvious and some subtle. One way that I have seen repeated the most often, is that they become much more eager to demonstrate their understanding: They want others to see what they are doing, how they are doing it, and share the results of their thinking in order to get feedback and learn even more. In a nutshell, student engagement and epistemic agency skyrocket. For me, seeing a student take pride in the work that they do, watching them find any amount of joy in their learning, *this* is the true power of Knowledge Building."

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Acknowledgments

We are grateful to Knowledge Building students, teachers, researchers, and in particular, Dr. Monica Resendes, Karen Dobbie, Elaine Hine, and Denis Maika, for their time and support. Their creative ideas and insight have been invaluable to our Knowledge Building.

Mobile Knowledge Building: Toward a New Conceptual Framework

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Abstract: This study of pervasive Knowledge Building with mobile technology in a grade 6 class was driven by a desire to bring work with ideas beyond specific times of the day and to advance knowledge creating practices. Toward advancing theory and practice, I explore the potential for a synergistic relationship between Knowledge Building and knowledge creation to produce an emerging conceptual framework. The framework utilizes the 12 Knowledge Building principles and knowledge creation's 4 modes of knowledge conversion to define a new framework, Mobile Knowledge Building. Aspects of this framework are illustrated in examples from ongoing research and early implications are discussed.

Introduction

Knowledge Building is a theory which envisions schools as knowledge creating organizations and students as active producers of knowledge (Scardamalia & Bereiter, 2014). Knowledge Building aims to provide ubiquitous opportunities for students' knowledge creation, without the confines of occasions or subjects (Scardamalia, 2017). Mobile devices offer opportunities for on-the-go learning (Hsu & Ching, 2015; Sharples & Pea, 2014), seamlessly moving across locations, time, and physical and digital spaces (Wong & Looi, 2011).

As Knowledge Building aims to prepare students for their futures in a knowledge society (Scardamalia & Bereiter, 2014), knowledge creation (Nonaka & Takeuchi, 1995), comparatively, attempts to formalize the operations of knowledge creating companies. Although the distinct challenges differ between Knowledge Building and knowledge creation (Bereiter & Scardamalia, 2014), I posit, that the possibility remains to explore a synergistic relationship between them.

Throughout research in a grade 6 class, the SECI model (Nonaka & Takeuchi, 1995; Nonaka & Toyama, 2003) was a helpful lens through which to interpret the exploratory study of pervasive Knowledge Building.

In this paper, I will present background literature and the emerging conceptual framework. Practices from early-stage research in a grade 6 class are interwoven into the theory to exemplify aspects of this framework.

Background

Knowledge Building

Knowledge Building emerged in the context of schools (Scardamalia & Bereiter, 2014) as a theory which envisions schools as knowledge creating organizations and students as active producers of knowledge. In absence of existing pedagogical theory for becoming knowledge creators, immersion in culture is the method of choice (Scardamalia & Bereiter, 2006), where students' work with ideas puts them on a trajectory to becoming mature knowledge producers (Scardamalia & Bereiter, 2003).

Knowledge Building engages students in distributed knowledge building processes (Hewitt & Scardamalia, 1998) in which students create artifacts, including writings and graphics (Scardamalia & Bereiter, 2014). Knowledge Building is fundamentally an endeavour mediated by artifacts (Stahl, 2002). Intersubjective meaning is shared and developed as virtual or physical objects (Ludvigsen et al., 2015). Those objects are the medium through which students collaboratively interact with their ideas (Stahl, 2002). These artifacts are available to the entire class and subsequently used as a foundation for more advanced artifacts (Hewitt & Scardamalia, 1998). Co-construction and archiving of these artifacts and processes is facilitated by Knowledge Building technology, of which Knowledge Forum (Scardamalia, 2017) is a prominent example. Knowledge Building, immerses students in a culture, guided by 12 principles (Scardamalia, 2002) and dedicated to the development of 21st century skills through their collective commitment to creating new knowledge (Scardamalia & Bereiter, 2014).

Popperian Epistemology: 3 Worlds

Knowledge Building treats ideas as real entities emerging but independent from the mental state of those who hold ideas (Scardamalia & Bereiter, 2014). Knowledge Building leverages the Popperian Epistemology (Popper, 1978).

In Popper's epistemology (Popper, 1978), there are 3 distinct, real, and interconnected worlds of objects: world 1 of physical objects, world 2 of psychological processes, and world 3 of ideas (products of the mind). From the physical world emerges living organisms and their world of mental processes; from mental processes emerge ideas which are distinct and independent from the mind that created them. Such objects can become objects of co-construction whereby multiple minds contribute to the development of ideas. Each emergent world has a profound ability to affect the world that created it; living organisms affect the physical world and ideas can profoundly affect the minds of individuals. However, of greatest importance (Popper, 1978, p. 159-160) is the articulation and criticism of ideas toward improvement of world 3 objects, including theories and plans. Finally, to become known by others, products of the human mind can be embodied in the world of physical objects (e.g. written plans, musical scores, or sculptures)—available for collaborative criticism and improvement.

Knowledge Forum

Knowledge Forum (Scardamalia, 2004) is a virtual environment utilized by Knowledge Building communities for embodying and working with ideas in a shared space. Membership within these communities is defined by contribution to these artifacts where the ideas and artifacts students produce represent their community knowledge (Scardamalia, 2002). The ability to extend and edit content enables computer support for the principle of *improvable ideas* (Scardamalia, 2002). Knowledge Forum brings together the worlds of knowledge creation and learning, where learning is necessitated by the continual creation and improvement of shared knowledge (Bereiter & Scardamalia, 2003).

Mobile Learning

Mobile learning is context-specific learning which takes place in real-world problems relevant and interesting to the learner (Traxler, 2009). As opposed to experimental research, which removes learners from their contexts of learning (Greeno & Engestrom, 2014), mobile learning is personal, contextual, and situated (Traxler, 2009).

Although learning in concrete contexts may have considerable value, Anderson, Reder, and Simon (1996) urge researchers to consider cognition as both context-dependent and context-independent and concrete instruction as able to be strengthened by abstract instruction.

In addition to networking people and knowledge, mobile devices also enhance the ability to pervasively capture and publish ideas. Students may capture and share phenomena to form a continual conversation with the external world, its artifacts, oneself, and others (Sharples, Taylor, Vavoula, 2010). This learning moves across time and physical or virtual spaces mediated by technology (Looi, Seow, Zhang, So, Chen, Wong, 2010). The aim of pervasive Knowledge Building is to provide ubiquitous opportunities for improving ideas and creation of knowledge (Scardamalia, 2017).

Knowledge Creation

Nonaka and Takeuchi (1995) formalize a generic model for organizational knowledge creation contextualized within the product development process of Japanese companies (p. ix). They credit the success of those companies on the companies' skills and expertise at *organizational knowledge creation*—the "capability of a company as a whole to create new knowledge, disseminate it throughout the organization, and embody it in products, services, and systems" (p. 3). Like Knowledge Building, which aims to move beyond learning, Nonaka and Takeuchi agree that organizations not only process knowledge but their ability to create knowledge is their most important source of international competitiveness (p. viii).

Nonaka and Takeuchi (1995) suggest that the "key to knowledge creation lies in the mobilization and conversion of tacit knowledge" (p. 56). Tacit knowledge typically lacks separability and transferability (OECD, 2013, p. 57), being embedded in human experience, beliefs, and values (Nonaka & Takeuchi, 1995, p. viii). Furthermore, insights of individuals are of little value unless they can be shared with others in the company (Nonaka & Takeuchi, 1995, p. 11). Knowledge creation is a spiralling process designed to cross the individual-organization boundary to amplify and network individual knowledge across and beyond the organization toward the emergence of organizational knowledge (Nonaka & Takeuchi, 1995). Similarly, in social learning, personal knowledge and experiences are shared and negotiated to bridge the competencies of people and communities (Wenger, 2000).

Organizational knowledge creation can be defined in terms of 2 dimensions: (1) the dimension between tacit and explicit knowledge and (2) the dimension between individual to inter-organizational knowledge (Nonaka & Takeuchi, 2003, p. 57). These can be mapped across four modes of knowledge conversion (Nonaka & Takeuchi, 1995, p. 72).

Setting

The examples used below as illustrations come from ongoing research with a grade 6 class focused on their work surrounding News. News may be interpreted as the time and place of dialogue, meaning-making, theorizing, and problem solving around local or global phenomena and events. Students are given the freedom to present news topics of their choosing (e.g. politics, video games, diets, racism, etc.), therefore, producing a relatively high level of interest and authentic engagement around ideas. Although there is no strict goal, students present and discuss articles while being encouraged to interpret, critically engage with, and "go deeper" to suggest theories or solutions regarding problems or events. Students work with ideas, advance their understanding, and move the class toward and beyond the existing frontiers of community knowledge.

Each topic provides a context-specific origin. Students reported thinking about News-related ideas while at-home or on-the-go but were unable to pervasively share and develop these ideas with their classroom community. In-class News discussions were restricted to a time and place causing many ideas to be cut-off and fail to be shared. Addition of Knowledge Forum was used to extend the time and space of News. Students were invited to use Knowledge Forum anytime throughout the school day (on portable laptops) or on personal devices at-home.

Exploring the Synergy between Knowledge Building and Knowledge Creation

The following sections of this paper describe the 4 modes of knowledge conversion (socialization, externalization, combination, and internalization) which compose the SECI model proposed by Nonaka and Takeuchi (1995). Each mode is defined and situated in the context of related theories, including Knowledge Building. Interwoven within the description of these modes of knowledge conversion, I offer examples from exploratory research, examining the relationship to class practices.

Socialization

Knowledge Creation

Knowledge creation starts with socialization, a process of acquiring new tacit knowledge through shared experiences (Nonaka & Toyama, 2003, p. 4). Nonaka and Toyama (2003) describe tacit knowledge as difficult to articulate but acquired through shared, direct experiences such as spending time together or living in the same environment (p. 4). This is exemplified in an apprenticeship relationship. These experiences may provide a common ground, helpful in the development of shared mental models.

The entire process of knowledge creation is necessarily tied to context, as knowledge creation requires time, space, and often relationship with others to occur (Nonaka & Takeuchi, 2003, p. 6). Nonaka and Toyama (2003) refer to this shared context in motion as *ba* (p. 6). Although tacit knowledge is context-specific, *ba* can exist in mental or virtual places no longer bound to space or time (p. 6-7).

Related Theories

As with situated cognition, where knowledge is "in part a product of the activity, context, and culture in which it is developed and used" (Brown, Collins, & Duguid, 1989, p. 32), socialization, rooted in tacit knowledge, is context-specific. Being bound to context requires that learning take place in a variety of contexts. Mobile learning, as argued by Looi et al. (2010), represents possibilities for learning that are ubiquitous, personal, and portable, using wireless devices to learn across time and physical space.

In addition to direct experience, the experience of and mediation with multimedia artifacts may provide community access to individual experience. Looi et al. (2011), describe the use of mobile technology during student inquiry as allowing students to capture phenomena from their everyday lives.

Although being in a shared context with others may involve language to help mediate tacit knowledge exchange, it is shared experience and apprenticeship which are descriptive of socialization. Within Knowledge Building, socialization is reflective of the enculturation of students into the situations and conditions of authentic work with knowledge (So & Tan, 2014).

Practical Exploration

Although direct experience may be better exemplified in non-News activities, News incorporates students' previous experiences and the development of community practices.

Shared experience is vital for putting oneself in another's thinking process (Nonaka & Takeuchi, 1995, p. 63). In News, students often share personal stories which relate to presented articles. During the discussion of an organized attack by vandals in a nearby city, students shared several stories relating to vandalism of their families' properties and possessions. This might allow for meaning-making around the news articles and generating a shared understanding. In some cases, sharing personal experiences was intentionally performed to make the discussion accessible and understandable to others, including researchers, such as the case with *Fortnite*, the videogame.

News in many ways is a training ground for students' work with ideas. News is a communal space for sharing News-related practices (i.e. collectively learning to present articles, critically engaging with news, constructively disagreeing, sharing personal experiences, and making sense of or proposing solutions to problems or events).

In the future, multimedia may play an important role in sharing local community practices. In a brief exploration, audio recordings of students' ideas were integrated into their work on Knowledge Forum. Although not yet fully-utilized, researchers came to realize that not only dialogue, but News practices, could be made known through these recordings, available to be shared with those who missed class or others from beyond the community.

Externalization

Knowledge Creation

Externalization holds the key to knowledge creation (Nonaka & Takeuchi, 1995, p. 66). Whereas socialization largely relies on direct- and shared-experience for the conversion of tacit knowledge, externalization makes tacit knowledge explicit so it can be shared (Nonaka & Toyama, 2003, p. 5). Even use of language is a form of externalization, but explicit knowledge can take physical form in diagrams, written documents, or other physical artifacts. Importantly, once knowledge is externalized, it can join the network of organizational knowledge (Nonaka & Takeuchi, 1995, p. 59) to be leveraged by the organization as a whole.

Related Theories

Bereiter and Scardamalia (2006) see conceptual artifacts as different from mental content, tacit knowledge, or embedded- or semiotic-objects, viewing them instead as theories, problem formulations, or interpretations in their own right. Such knowledge is a world 3 object. Popper (1978) proposes, however, that most world 3 objects can be embodied or physically realized in physical objects. These become the knowledge artifacts (Ludvigsen, Stahl, Law, Cress, 2015) that are central to collaborative efforts in the field of Computer Supported Collaborative Learning. This codification of personal or tacit knowledge into explicit knowledge is what becomes available to the broader community for feedback and improvement.

If the theory of *pervasive knowledge building* (Scardamalia, 2002) is applied not only to a mind-set of working with ideas but to pervasively externalizing personal knowledge, this may radically promote the principles of *democratization of knowledge* (Scardamalia, 2002) and *idea diversity* (Scardamalia, 2002), two principles vital for ideas to evolve. This opportunity may become a real possibility using mobile technology.

Practical Exploration

Traditionally, the group work with news-related ideas was restricted to a particular time and place. The integration of technology enabled a more pervasive practice where students were free to share ideas during or outside of News—to capture ideas which otherwise would not have been captured or shared. Capturing offline discourse became an important aspect of this endeavour—to collect ideas not captured in-class and embody news discussions (mainly in text or audio) for revisiting, sharing, and building-on in the future.

As for the other aspect of explicit knowledge, the formation of context-general concepts and perspectives, these were found to arise from the natural progression of many discussions. In the discussion of a restaurant's record-breaking 111-cheese pizza, the ideas progressed from talking about pizza to human adaptation and origins of consuming other animals' milk to the paradox of individuals being lactose intolerant but able to drink milk as an infant. In other discussions, new or revisited concepts entered their repertoire. A discussion of China's constitution permitting a president-for-life led the class to revisit systems of governments and introduce the new concept of an oligarchy and how that related to this situation. Another new concept, elegantly introduced, was of satire and satirical news, introduced through the unintentional presentation of a satirical article about babies entering the United States, taking Americans' jobs, and threatening their country.

Combination

Knowledge Creation

During combination, different bodies of explicit knowledge are combined (Nonaka & Takeuchi, 1995, p. 67). Once knowledge is codified in language and symbols, it can be effectively shared within an organization. This networking of knowledge, Nonaka and Takeuchi (1995) explain, occurs with both recently created knowledge and existing knowledge from other sections of the organization (p. 71). This, they suggest, is most like the common educational practices of working with formalized, largely context-free knowledge. Creative use of computers as communication networks can be used to disseminate explicit knowledge and facilitate combination of knowledge (Nonaka &

Toyama, 2003, p. 5). With knowledge creating companies, they tend to operate in open systems, learning from and sharing knowledge with those beyond their organization (Nonaka & Takeuchi, 1995, p. 84-85).

Related Theories

According to Popper (1978), world 3 objects, such as theories, can be improved through cooperative critique and contribution (p. 163) as it is this improvement of world 3 objects that is of the greatest importance (p. 160). Once knowledge is articulated as a knowledge artifact in a shared space it can become an *improvable idea* (Scardamalia, 2002), able to be advanced by the community. It is the creation and improvement of c*ommunity knowledge* (Scardamalia, 2002) that is central to combination.

Knowledge Forum is a collaborative space for carrying out Knowledge-Building work and for fostering continual improvement (Scardamalia, 2004). Knowledge has inherent logical characteristics (Popper, 1978; Scardamalia & Bereiter, 2014) whereby Knowledge Forum can logically situate, combine, or re-use ideas and knowledge artifacts outside of their original contexts.

Aligning with the work of combining explicit resources from within and beyond the organization, *constructive uses of authoritative sources* (Scardamalia, 2002) reaches beyond the local fringe of community knowledge to combine with and extend community knowledge. *Knowledge building discourse* (Scardamalia, 2002) may take place within a single classroom or across the world (Scardamalia, 2004). Furthermore, a current opportunity and challenge for Knowledge Building research is fostering these cross-community interactions (Zhang, Bogouslavsky, & Yuan, 2017).

Practical Exploration

Prior to using Knowledge Forum, work with ideas lasted from the start until the end of one News session. After the addition of Knowledge Forum, without instruction or prompt, students on occasion began revisiting old concepts to build-on and work with those ideas.

Although not yet utilized, experimentation with audio recordings of news presentations has opened the door to sharing knowledge and experiences with others beyond the community, allowing others to engage with the interpretations, questions, and theories of the local community.

Logically situating and combining ideas was exemplified during a demo of view organization with students. A researcher was illustrating how concepts can be organized into separate Knowledge Forum views, at which point one student asked what she could do if a concept was related to multiple topics. This created a smooth transition to a demonstration of the *rise-above* (Scardamalia, 2002) and reference features, and how they can be used conjointly to represent interrelations and complex interactions between ideas.

Internalization

Knowledge Creation

Internalization embodies explicit knowledge into tacit knowledge, when knowledge from socialization, externalization, and combination all become internalized (Nonaka & Takeuchi, 1995, p. 69). Internalization relates to learning-by-doing and putting abstract theories or knowledge into concrete practice; knowledge is applied to practical situations (Nonaka & Toyama, 2003, p. 5). Practices may be informed and improved based on newly acquired explicit knowledge. Individuals may read knowledge in documents to improve their own tacit knowledge or they may embody knowledge through simulations or experiments (p. 6).

For organizational knowledge creation to complete the spiral back to socialization, Nonaka and Takeuchi (1995), point out that new individual tacit knowledge must be socialized with other members of the organization, helping others to re-experience individuals' experiences to become tacit mental models shared by the organization and established as part of the organizations culture (p. 70).

Related Theories

Internalization is key to creating value for an organization. As Nonaka and Takeuchi (1995) describe this mode, concepts are used in real-world situations, allowing people to improve their practice. From a Popperian (1978) perspective, this is where world 3 ideas have a tremendous impact on the physical world. According to Bereiter (2014), this is the bridge between theory and practice; this is where knowledge-based capital (OECD, 2013) is embodied in individuals as tacit knowledge.

Returning from explicit to tacit knowledge involves putting theoretical knowledge to practice. This concern is voiced by the principle of *real ideas, authentic problems* (Scardamalia, 2002), in which students are encouraged to engage with problems they really care about, typically moving beyond toy problems and puzzles from textbooks.

The importance of reflection and improvement of community practices are reflected in the principle of *embedded and transformative assessment* (Scardamalia, 2002). To close the spiral of knowledge conversion, *symmetric knowledge advancement* (Scardamalia, 2002) occurs when individual knowledge advances are brought back and exchanged with others. Although both combination and socialization have elements of symmetric knowledge advancement, socialization emphasizes this exchange as a social practice.

Practical Exploration

Returning ideas to practice was exemplified by a student with an interest in aircraft. He was designing his own airline as a school project. When assessing which aircraft to use for his airline and whether the aircraft would be able to travel the required distances, he began talking about the different types of airplanes. Suddenly, he realized that he had learned relevant information during his preparation for a prior News presentation about a plane that run out of fuel. Therefore, knowledge from news was applied to a practical problem and class deliverable.

Discussion

Toward a New Framework

The following framework represents a work-in-progress, elaborating and contextualizing knowledge creation and pervasive Knowledge Building supported by mobile devices. This paper gleans insights from past theories and presents glimpses into exemplars from ongoing research. The examples represent a perspective of student practices through the lens of the emerging framework. Figure 1 illustrates the proposed framework, which reconceptualizes and integrates the 4 modes of knowledge conversion (Nonaka & Takeuchi, 1995) with the 12 Knowledge Building principles (Scardamalia, 2002):

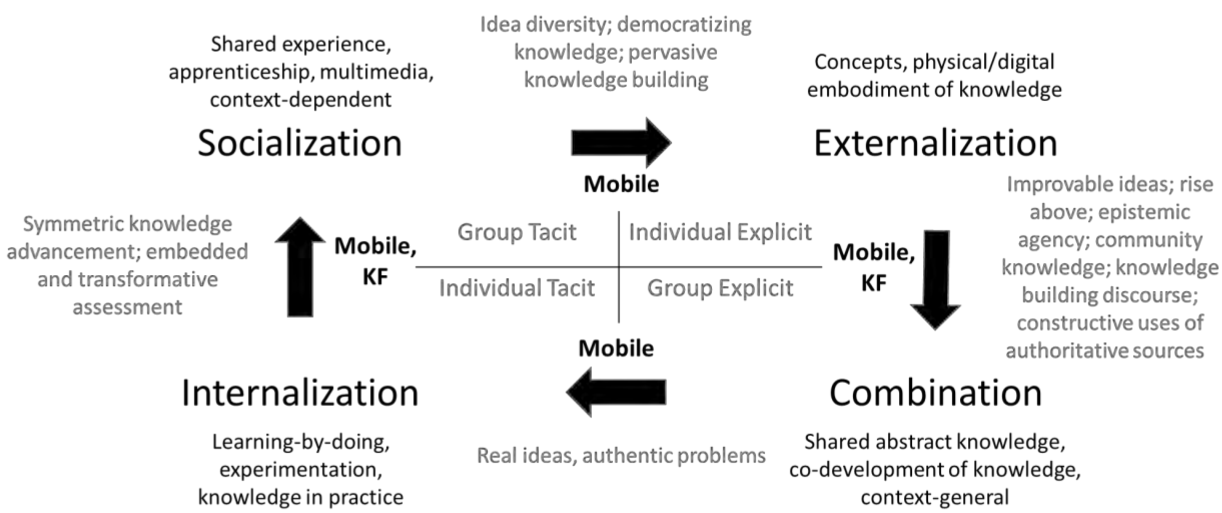

Figure 1. Toward a Mobile Knowledge Building Framework.

Implications

This paper proposes an admittedly bold framework which combines the context-specific qualities of mobile learning with the context-general qualities of Knowledge Building through integrating with and reconceptualizing the 4 modes of knowledge conversion. This model has implications for the uses of mobile devices, knowledge artifacts, and the community which emphasize knowledge mobilization of and pervasive work with ideas across time and space.

Although Knowledge Building can occur anywhere along the context-specific to context-general continuum, it is biased toward the context-general end which is where design work happens, creating and improving broadly relevant theories, problem formulations, and interpretations (Bereiter & Scardamalia, 2006). The complement of mobile devices may promote seamless movement across contexts and bridging the gap between abstract and experiential learning.

The SECI model began as a lens through which to view an exploratory study of pervasive Knowledge Building with mobile technology. Throughout the ongoing study, this conceptual framework was adapted, refined, extended to form the current iteration.

In overview of Mobile Knowledge Building: (1) people learn, in part, from the world, collectively sharing community practices, (2) their knowledge is articulated in words and concepts, built into Knowledge Artifacts, (3) knowledge, thus, becomes distributed across people and objects to be developed, and (4) ideas are fed back into the world through new applications and practices informed by new knowledge. This prompts classes to create ideas of value and impact which avoid a common problem in education: what happens in-class stays in-class.

This model exists as a highly simplified model of complex and fluid interactions and transformations which should not be taken too seriously as a phased or cyclical approach. Additionally, in Figure 1, Knowledge Building principles may be applied at various positions within the model, but I find them particularly descriptive of their assigned positions.

This framework awaits further refinement, development, and implementation with classes which may attempt increasingly pervasive practices, extending across subjects, students' lives, additional forms of multimedia, and even across communities to represent a system-wide initiative to create new knowledge.

Acknowledgment

I thank my colleagues and friends from the Institute for Knowledge Innovation and Technology (IKIT) who encouraged me to continue writing this paper and provided inspiring conversations, necessary corrections, and valuable insights.

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Learning from Cross-boundaries Collaboration in Knowledge Building Communities with the Support of Idea Thread Mapper

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Abstracts: This paper presents findings from the second iteration of a design-based research study aimed to support cross-classroom interaction in four grade 5 knowledge building communities. The four classrooms studied human body systems with the support of the Idea Thread Mapper platform over five months. As the students conducted focused inquiry and discourse within their own community, they reviewed productive threads of ideas and posted "journey of thinking" reflections in a cross-community space, as synthetic boundary objects. Extending the previous year's design. This iteration incorporated a new interaction for the four classrooms to participate in a live "Super Talk" to collaboratively address challenging research questions. Qualitative analyses of classroom videos, online discourse, and researchers' field notes provide a rich description of how the students interacted within and across communities to pursue deepening discourse and develop scientific understandings.

Introduction:

Educational researchers have made substantial advances to develop collaborative learning environments and support collaborative knowledge building among students (Engle & Conant, 2002; Scardamalia & Bereiter, 2006; Slotta, Suthers, & Roschelle, 2014). Further research is needed to extend the collaborative interaction to higher social levels and scales (Stahl, 2013) so students can build on the knowledge of other communities across school years for sustained knowledge building (Zhang, et al., 2017). The purpose of this design-based research is to test and refine designs of cross-classroom interaction for knowledge building with the support of a new collaborative platform: Idea Thread Mapper (Zhang, et al., 2018).

Existing explorations of cross-community interactions for knowledge building adopted a single layer interaction design. Each classroom gave other classrooms access to their online discourse space so they could read their notes and respond, supplemented with periodic video conferences (Laferrière et al., 2012). The findings suggest productive classroom changes. Meanwhile, difficulties arose for students in understanding other communities' ideas and discourse without a clear sense of the contexts. New strategies of boundary-crossing support are needed to make knowledge progress accessible across communities.

This research designs cross-community interaction using a multi-level emergent interaction approach, focusing on interactions mediated through boundary objects. "Boundary objects" are artifacts (e.g. reports, tools, models) used to bridge the boundaries (discontinuities) between different social worlds (Star & Griesemer, 1989). Objects from a community often have contextual meanings that are not accessible to other communities. What makes boundary objects effective for bridging different communities of practice is their interpretative flexibility as a "means of translation" (Star & Griesemer, 1989): they have a structure that is common enough to make them recognizable across the different social worlds and allow different communities to interact and work together. Through interacting with shared boundary objects, members from different communities can identify, understand, and reflect on their different practices, leading to enriched understandings within each community and potentially the creation of new in-between practices (Akkerman & Bakker, 2011).

As noted above, raw distributed online discourse records are hard to use as boundary objects to bridge different knowledge building communities. Therefore, we developed a multi-level emergent interaction approach (Zhang, Bogouslavsky & Yuan, 2017; Yuan, Zhang & Luo, 2018). Students in each community engage in focused inquiry and interactive discourse within their own community's space. As progress is made, students selectively synthesize fruitful threads of inquiry that emerge from their discourse. The reflective reviews and syntheses can facilitate peer learning and build-on within each classroom (Zhang & Yuan et al., 2018); they may further be shared as boundary objects to enable cross-community interaction. Students from other partner classrooms (or a subsequent student cohort) can use the syntheses of idea threads to view into the progress of inquiry and build connections.

We have conducted a multi-year design-based research to test and refine the multi-level interaction design (Zhang, Bogouslavsky & Yuan; Zhang & Yuan, 2018). The earlier iterations/designs were supported by purposeful uses of existing tools offered by Knowledge Forum (Scardamalia & Bereiter, 2006). On the basis of the findings, we created and upgraded a new collaboration platform: Idea Thread Mapper (ITM) (Zhang et al., 2018), which interoperates with Knowledge Forum. ITM supports knowledge building interaction in a network of "buddy classrooms". Students in each classroom co-organize "juicy" wondering areas (shared inquiry foci) as they pursue interactive discourse to deepen their understandings in a domain area. They compose Journey of Thinking syntheses to review progress in each area, focusing on (a) overarching topic and problems, (b) "we used to think…now we understand"… and (c) deeper research needed. The wondering areas and syntheses are shared in a cross-classroom space that has an easy search tool. As a newly designed feature, ITM allows different classrooms to initiate and participate in live "Super Talk" threads to collaboratively address challenging problems.

This paper reports a new iteration of this design-based research to refine cross-classroom interaction in a set of four grade 5 classrooms supported by ITM. Our research questions ask: (a) How did students generate Journey of Thinking syntheses for cross-classroom sharing and interaction? (b) How did the four classrooms initiate and pursue "Super Talk" to address challenging problems? And (c) in what ways did the within-classroom discourse and cross-classroom "Super Talk" interact to support deep inquiry and understanding?

Methodology

Classroom design and contexts

This study was conducted in four grade 5 classrooms (with a total of 89 students) that studied human body systems over a six-month period using ITM. The four classrooms, labeled as Class 1-4, were taught by two teachers each teaching two classes. Students in each room generated interest-driven questions, co-organized wondering areas focusing on various human body systems, and conducted research using various resources. They conducted knowledge-building conversations (called "metacognitive meetings") in their classroom to build on one another's questions and ideas. The conversations continued on ITM in their online discourse space organized as various idea threads each addressing an overarching problem/theme. As progress was made in each idea thread, students co-created and edited "Journey of Thinking" to reflect on their knowledge (Figure 1). The "Journey of Thinking" was then shared with all the other classrooms. Drawing on their knowledge built up about the various body systems, students in class 3 proposed a challenging problem for "Super Talk" across the classrooms: How do people grow? (Figure 3). The proposal was supported by the other classrooms. Students from different classrooms worked together to discuss this overarching question collaboratively. Near the end of the unit, each class had a metacognitive meeting to review knowledge gained from the "Super Talk" and to build connections with the different human body systems.

Data Sources and Analyses

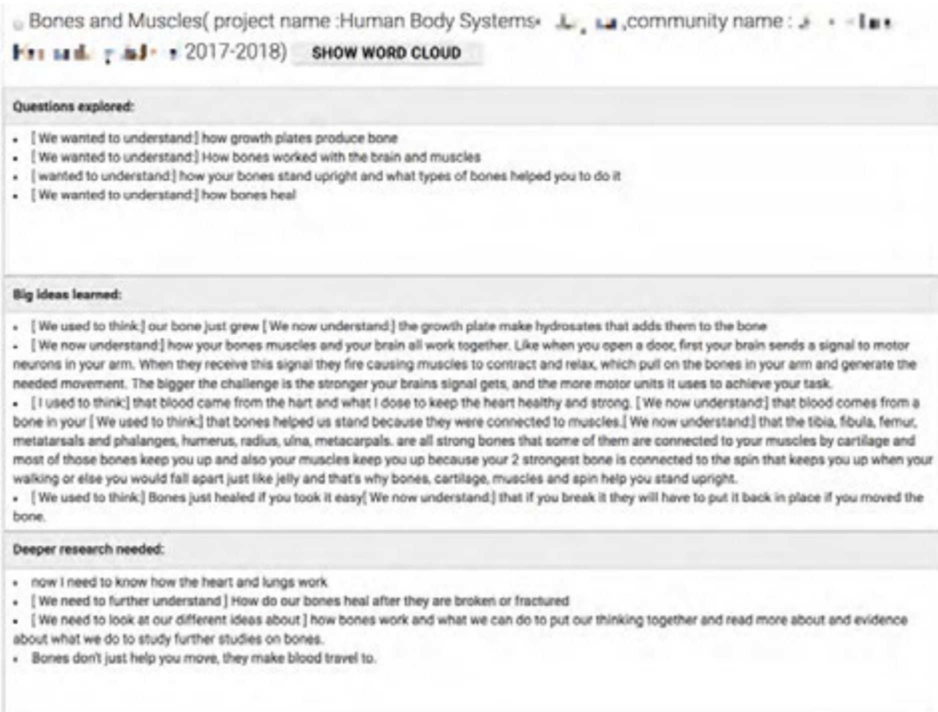
The data sources included classroom observation notes, video records and transcriptions of classroom conversations, and students' online discourse on ITM and "Journey of Thinking" shared in the cross-classroom space. Guided by each of the three research questions, we conducted detailed qualitative analysis of student research activities in their home class in connection with student cross-classroom collaboration. To analyze the quality of students' Journey of Thinking syntheses, we conducted content analysis (Chi,1997) based on the scientific levels (from pre-scientific to scientific) and complexity of ideas (from unelaborated facts to elaborated explanations) (Zhang et al., 2007). To understand how the Super Talk took place, we read/re-read our detailed field notes and examined the classroom videos to understand the classroom processes. To understand how the within-classroom discourse and cross-classroom Super Talk interacted to support deep inquiry, researchers selectively transcribed three metacognitive meeting videos from each class. A discourse analysis of metacognitive meetings was applied to examine in what ways the within-classroom discourse and cross-classroom "Super Talk" interacted to support deep inquiry and understandings.

Results

RQ1. How did students generate syntheses of Journey of Thinking for cross-classroom sharing and interaction?

Students engaged in kick-off activities eliciting their interests about the human body in January 2018. Students in each room generated various interests and questions and formulated overarching "wondering areas." These areas became the focus of the subsequent inquiry by individuals and groups using books, online resources, and models. With inquiry progress made in the next two months, students were introduced to the Journey of Thinking function in ITM. Focusing on each area of inquiry, students added reflections on their research individually, and then compiled the reflection entries into whole group Journey of Thinking (Figure 1). The syntheses of Journey of Thinking were then shared with all the other classrooms in the cross-classroom sharing space.

To examine the quality of student reflection in the Journeys of Thinking, researchers coded student ideas summarized under "We used to think" and "Now we understand" based on scientific sophistication and epistemic complexity (Zhang et al., 2007) (see Table 1). Ideas summarized under “Now we understand” show a high level of scientific quality and complexity. Compared with the previous year of this design-based research in which we tested a similar design without ITM, the “Journey of Thinking” syntheses had more words on average (362.3 versus 170.8 words), and the ideas summarized under “Now we understand” are more scientific and complex, suggesting improvement to student reflective inquiry.



Bones and Muscles(project name :Human Body Systems ,community name : 2017-2018) SHOW WORD CLOUD

Questions explored:

- [We wanted to understand:] how growth plates produce bone
- [We wanted to understand:] How bones worked with the brain and muscles
- [wanted to understand:] how your bones stand upright and what types of bones helped you to do it
- [We wanted to understand:] how bones heal

Big ideas learned:

- [We used to think:] our bone just grew [We now understand:] the growth plate make hydrosates that adds them to the bone
- [We now understand:] how your bones muscles and your brain all work together. Like when you open a door, first your brain sends a signal to motor neurons in your arm. When they receive this signal they fire causing muscles to contract and relax, which pull on the bones in your arm and generate the needed movement. The bigger the challenge is the stronger your brains signal gets, and the more motor units it uses to achieve your task.
- [I used to think:] that blood came from the hart and what I dose to keep the heart healthy and strong. [We now understand:] that blood comes from a bone in your [We used to think:] that bones helped us stand because they were connected to muscles.[We now understand:] that the tibia, fibula, femur, metatarsals and phalanges, humerus, radius, ulna, metacarpals. are all strong bones that some of them are connected to your muscles by cartilage and most of those bones keep you up and also your muscles keep you up because your 2 strongest bone is connected to the spin that keeps you up when your walking or else you would fall apart just like jelly and that's why bones, cartilage, muscles and spin help you stand upright.
- [We used to think:] Bones just healed if you took it easy[We now understand:] that if you break it they will have to put it back in place if you moved the bone.

Deeper research needed:

- now I need to know how the heart and lungs work
- [We need to further understand] How do our bones heal after they are broken or fractured
- [We need to look at our different ideas about] how bones work and what we can do to put our thinking together and read more about and evidence about what we do to study further studies on bones.
- Bones don't just help you move, they make blood travel to.

Figure 1. The Journey of Thinking synthesis written for the Area of Bones and Muscles from Class 1

Table 1: Comparison of Coding of ideas in the “Journey of Thinking” summarized under “We used to think” and “Now we understand.” between 2017 and 2018.

	Journey of Thinking			
	2018		2017	
	We used to think	Now we Understand	We used to think	Now we Understand
Scientific Sophistication				
Pre-scientific	33%	0%	38%	0%
Hybrid	50%	0%	48%	0%
Basic	16.7%	0%	14%	18%
Scientific	0%	100%	0%	82%
Epistemic Complexity				
Unelaborated Facts	83%	%	95%	9%
Elaborated Facts	0%	16.7**%**	0%	32%
Unelaborated Explanations	16.7%	0%	5%	9%
Elaborated Explanations	0%	**83.33%**	0%	48%

RQ2. How did the four classrooms initiate and pursue Super Talk to address challenging problems?
In the beginning of May, at a metacognitive meeting, students in class 3 noticed the new ITM feature of "Super Talk." The teacher explained that this function was for all the classrooms to explore big challenging questions and put their knowledge together. Then Class 3 started to discuss possible challenging questions for Super Talk. Three questions were proposed in total: How are all the systems connected? Which two systems are most connected? and Why do people grow? A few students reflected on what they knew about how muscles grow, and several other students showed interest in the growth topic, as they had grown a lot during the school year. Then they agreed to focus on one topic for the Super Talk and decided to have a vote for the one that they felt was challenging and which they were most excited about. The topic of "How do people grow?" was selected. This Super Talk topic was proposed and added in ITM and visible to other classrooms. In the following week, students from Class 3 first started to contribute knowledge about how the brain, bones and muscles grow, drawing upon their knowledge about these body systems. The teachers then started to advertise the "Super Talk" question in other classrooms. Teachers read the notes already posted by Class 3 and discussed what counts as a good note for the Super Talk. In the following week, students from the other classrooms started to build on the ideas in the Super Talk (Figure 2).

Student A from Class 4, studying the digestive system and energy, found the connection with muscles, so he added more detailed information and "helped out" in answering the big question by adding that muscles need energy ATP (Adenosine Triphosphate). Also Student B from Class 2 built on this idea, saying: "*Muscles grow by when you stress muscle fibers by lifting heavy weights or doing motions you're not used to, they rip which lets out a chemical called cytokines which activates your immune system which repairs it bigger than it was earlier which makes your muscles grow. Hypertrophy is how your muscles say you need to work more to make your muscles grow.*" At the same time, a new angle of viewing was realized by Student C from Class 1, who wrote about how sleep affects growth as related her inquiry of the brain. Her post highlighted that during the Non-Rapid Eye Movement stage (NREM), the body is actually repairing damaged tissues and growing. And new detailed information about bones was expanded and explained by Student D from Class 2 who was studying bones, as he mentioned that *"bone grows from cartilage, they fuse together and go through a process called Ossification."* Later, his peer who studied the same topic built on his note and added more a detailed description of the process of ossification: *"Over time, a different type of cells called osteoclasts head to the middle of the bone to help in. Now, inside osteoclasts there are hydrolytic enzymes and acids. These enzymes and acids will help dissolve the temporarily bone (the cartilage) to make room for the permanent bone (marrow)."* Towards the end of the online discussion, Student E from Class 1, who was studying the endocrine system, gave her explanation from the angle of the endocrine system, because the pituitary gland releases a hormone that controls the growth as it plays a huge role in puberty and metabolism. A cross-cutting connection was further built when Student F from Class 2, who was studying cells found that humans start as cells and all the organs are made of cells, and the way cells grow is from mitosis, and cell growth is how humans grow. He imported his note about mitosis into the Super Talk, which triggered deeper conversation in other classrooms' face-to-face meetings.

The Super Talk extended till the end of May with a total of 22 students from the four classrooms participating in the discussion. Students collaboratively explained how people grow from bone and muscles, brain and nervous systems, cells and genetics, and digestive systems. Approximately 50% of the notes are build-ons, reflecting a higher level of collaborative responses. Student notes were coded based on epistemic complexity (Zhang et al., 2007), with 86% of the notes offering elaborated explanations beyond simple facts.

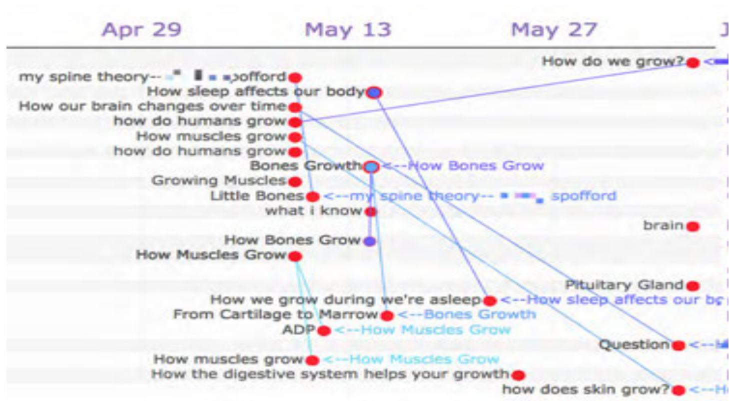


Figure 2. The cross-classroom Super Talk about how people grow. Each dot shows a note, and a line between two dots shows a build-on connection. Each note was position-based on the date of creation (x-axis) and author (y-axis).

RQ3. In what ways did the cross-classroom "Super Talk" leverage deeper discourse and inquiry in each classroom

In early June, each class held a face-to-face metacognitive meeting to revisit the question of how people grow. The discourse analysis showed that students brought what they had learned from the "Super Talk" back to their home class discussion and made further connections with the growth of other organs, leading to deepened understandings of the human body systems (see the following excerpt for an example).

135 Teacher: Your brain cells are dying? or not making a new one?
136 S8: You are not making new ones, but they do start out, they do die as you get older
137 S5: When you run out of brain cells you die?
138 S12: I saw something on Knowledge Forum about chromosomes, it is kind of related to growth. What is it, can you reiterate it?
139 Teacher: What are chromosomes are related to?
140 S7: Mitosis?
141 S5: DNA?
142 Teacher: Oh, Mitosis? what about DNA? what's that related to?
143 S5: DNA and RNA.
144 Teacher: What is that related to?
145 S8: RNA is just half of DNA
146 S12: Mitosis is the process of one cell split into two new cells, it is a complex process of many steps. one prophase. Prophase are the structures called centrioles move to opposite ends of the cell and fibers come out of them and enclose the cell. And metaphase are chromosomes line up in the center of the cell. Each attaches to two fibers. chromosome halves pull apart the cell and divide the membrane. Step three is anaphase and step 4^{th} telophase.
147 Teacher: He is talking about really deep science that behind this (pointing to the drawing) where the one cell is splitting into two equal parts. So when you cut an apple, you know, in the center of the apple gets really cut in half, it really does, that's not the same as what is going on here. with mitosis, it gets cut in half but each half gets exactly the same the central part. like the same center of the apple grows into both pieces, when it splits apart, and then that's...they split apart to make two identical, and it still has that center of the apple, and what's in the center in the apple, or the center of the cell?
148 S: The DNA:
149 S2: Chromosomes
150 Teacher: DNA and chromosomes, and what can you tell us about heredity or DNA
151 S: Hair color, eye color.
152 S17: Your genes there are like the blueprint.

The teachers played a crucial role in embracing the ideas from other communities to extend students' learning, using child-friendly language to leverage students' understanding, and making connections with other topics in current classroom.

Implication

This study tested a multi-level emergence design of cross-community interaction, with students engaging in focused inquiry and discourse within their own classroom while generating reflective "Journey of Thinking" as boundary-crossing objects, and participated in the "Super Talk" to investigate a challenge problem together. The results provided an elaborated account of the processes to generate reflective syntheses and pursue Super Talk. Students built on knowledge building interactions through the cross-classroom collaboration to extend and enrich the discourse in their home class. Expanding our previous year's work, the findings from this design-based research study shed light on the possible designs and processes to enable collaborative knowledge building across a network of classrooms in a larger scale. These research results also provide an initial insight that may help teachers to conduct new teaching strategies by adopting cross-classroom interaction patterns in extending and leveraging current classroom learning.

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Acknowledgments

This research was sponsored by National Science Foundation (IIS#1441479). We thank the teacher and students for their creative work enabling this research.

The Use of Knowledge Building Scaffolds by Grade 7 Students

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Abstract: Knowledge Forum has some unique features called scaffolds which allows students to take more agency on their learning and help them build and refine theories through Knowledge Building discourse. Using the scaffolds appropriately will help them take advantages of this feature. Therefore, if students perceive and use Knowledge Building scaffolds appropriately, and what support teachers provides to students to help them appropriately use the scaffolds need to be explored. We investigated these questions with a content analysis of students' Knowledge Forum notes and the teacher's reflections on the scaffold usage. The results showed that overall, the students had no problem using the theory development scaffolds such as "I need to understand", "my theory", and "new question", but they rarely used theory refinement scaffolds such as "this theory cannot explain", "putting our knowledge together" or "a better theory" nor could they use the theory refinement scaffolds appropriately; in the productive threads, the teacher and students tended to use theory refinement scaffolds while in the threads that need further improvement, they mainly used theory development scaffolds; and the teacher indicated that the kids were cautious to move into areas such as relating what they learnt to real-world issues, connecting their ideas and synthesizing new knowledge, and they needed support and time in these areas.

Introduction

When interacting with other students, individuals may contribute different perspectives that they have gained because of their diverse backgrounds such as race, language and prior knowledge (Kim, 2001). Interacting with more capable people such as teachers and peers may help individuals perform a task that is slightly beyond their ability and in the zone of proximal development. The zone of proximal development refers to "the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers (Vygotsky, 1978, p.86)". The process of assisting and guiding learners to what they may be able to achieve with help is called scaffolding (Murphy, 1997).

Collaboration scripts are scaffolds that structure the interactive processes between collaborators (Kollar, Fischer, & Hesse, 2006). Student collaboration needs to be supported to help them yield performance and learning benefits since some students are not able to interact with others in expected ways or do not show collaborative behaviours that closely relate to learning (Diziol, Walker, Rummel, & Koedinger, 2010). Collaboration scripts vary in the degree of constraints they provide to structure students' learning. Either fixed collaboration scripts with certain sequence of interaction phases or designed roles and activities for students or open collaboration scripts with a greater deal of freedom for students to engage in high-level activities such as explaining or commenting can be implemented to support interaction and learning (Kollar et al., 2006). Some of the fixed collaboration scripts have been shown to be effective in supporting collaborative learning, such as the jigsaw scripts or the reciprocal teaching script (Dillenbourg & Jermann 2007). However, the fixed scripts also show their disadvantages of "over scripting" which may reduce students' motivation to interact, especially for those who are skilled at collaborating or who do not like coercive external control over their collaboration process (Dillenbourg, 2002). Researchers such as Lepper, Drake and O'Donnell-Johnson (1997) suggested that scaffolds must emphasize student agency. In contrast, open collaboration scripts allow those with adequate knowledge and skills to engage in collaborative situations to effectively learn and collaborate while may cause problems for the students who do not have enough collaborative strategies or do not know how to deal with the freedom (Kollar et al., 2006).

Knowledge Building scaffolds, also titled "thinking types" and "epistemic discourse markers" (Resendes, Scardamalia, Bereiter, Chen, & Halewood, 2015; Scardamalia and Bereiter, 1983), is the most imitated feature of Knowledge Forum. Collective theory building and improvement is a complex work. It requires students to generate questions that they wonder about, seek and integrate information, propose explanations, connect different ideas and information, identify weakness of existing theories and ask further inquiry questions, achieve new syntheses and so forth (Goldman & Scardamalia, 2013). Knowledge Building is a pedagogical approach to support collective theory building and improvement, and the twelves principles (e.g., real ideas/authentic problems, improvable ideas, idea diversity, rise above, community knowledge/collective responsibility) of Knowledge Building distinguish it from other constructivism approaches (Scardamalia, 2002). In Knowledge Forum – an online space designed to support the aforementioned ways of contributing in Knowledge Building (Scardamalia, 2004), scaffolds are implemented to help shape Knowledge Building discourse (Scardamalia & Bereiter, 2006). For example, scaffolds like "my theory is", "new information", "put our knowledge together" may help students construct their knowledge as a community, and scaffolds like "this theory cannot explain", and "a better theory" may help students refine their community knowledge (Scardamalia, 2004).

Knowledge Building scaffolds can be used in any order and can be customized. Rather than being designed as scripts to ensure that students follow certain orders when working on assigned tasks, Knowledge Building scaffolds aim to help students engage in high-level knowledge processes and work with emergent knowledge improvement needs (Scardamalia & Bereiter, 2003; Zhang, Hong, Scardamalia, Teo & Morley, 2011). For example, when facing some existing information or explanations built onto a community question, a student can use "this theory cannot explain" if she found the weakness of a theory, can use "put our knowledge together" if she connected and synthesized different theories, can use "a better theory" if she provided a more coherent explanation, and she may also use "new information" or "my theory" to provide more information or theories to make the conversation more diverse. Knowledge Building scaffolds can easily be modified to support students' progressive discourse in different content areas and in different levels of education (Zhang et al., 2011). For instance, in science, scaffolds related to experimentation may be developed; in primary schools, teachers and students may modify the scaffolds to make them more kid-friendly.

Previous studies indicate that students' perception and interpretation of scaffolds influence scaffolds usage and vary for different individuals and time. For instance, Shabo, Guzdial and Stasko (1997) found that students hesitated to use scaffolding when they were unable to interpret the features of scaffolding; they tended to use scaffolding when given explicit instructions on how to use it. Sharma and Hannafin (2005) indicated that students' perception of the use of scaffolding varied for each participant and changed over time. At the beginning, they perceived the scaffolding as what the instructor wanted them to do, and gradually they perceived the scaffolding as something that could direct their thinking along meaningful directions. Sharma and Hannafin (2005) also suggested that instructions on scaffolding purpose and use would help students appropriately use scaffolds.

As an important feature of Knowledge Building and Knowledge Forum, the use of scaffolds has not been given much attention. In several studies, researchers (e.g., Resendes et al., 2015) looked at the frequency of different scaffolds used by students. Resendes et al. (2015) indicated that when reflecting on the frequency of their used scaffolds, the students could accurately evaluate their scaffolds usage and engage in discussion on scaffold growth, and they tended to realize to use the scaffolds that were rarely picked up in their previous notes. Scardamalia and Bereiter (2006) showed that when Grade 3 students found that they used too much "did you know" to record information from textbooks or online materials, they decided to use other scaffolds to move from knowledge telling to knowledge building discourse, indicating that even young students could collectively make decisions on scaffolds to support their progressive discourse. However, as a kind of scaffolding which is relatively open and allows students more agency, whether Knowledge Building scaffolds are interpreted and used appropriately by students is unclear, and what kinds of support students get from teachers also need to be explored. Therefore, in this study, we aim to explore the following questions:

1. Do students use Knowledge Building scaffolds appropriately in their notes, and what scaffolds do they use over time?
2. How does scaffold usage influence idea improvement?
3. What kinds of support does a teacher provide his/her the students to use scaffolds more appropriately, and why do the students use scaffolds in a certain manner from the teacher's perspective?

Methods

Data sources and classroom context

The dataset for this study included 217 Knowledge Forum notes contributed by 32 Grade 7 (Secondary One) students in a science class in Singapore and the teacher's description and reflection of the context, especially scaffold usage of the class. The students worked on "Human Digestion System" for about two months in Knowledge Forum. The students had some experiences with Knowledge Building and Knowledge Forum. They were able to navigate in Knowledge Forum, to write their notes, to read and to build on their peers' ideas. Over the span of two months, the students mainly worked in two views: 1) "Digestion" in which they worked on the questions generated by each student, and 2) "Digestion Extension" in which they mainly studied enzymes.

When the class was over, the teacher reflected on the Knowledge Building journey with a focus on scaffolding usage based on the questions generated by the researchers. Example questions are:

1. Did you introduce the scaffolds to the students? If so, could you please describe what did you do and how did the students respond?
2. We noticed your class constructed some new scaffolds such as “My question is”, “I wonder why”, “My idea is”, “What I found online”, “New information I found”, “Can you explain further”, “This idea cannot explain” and “Combining our ideas.” Could you please explain how did you do this?
3. The students mainly used “My theory” and “New information”. What do you think are the possible reasons?
4. We found some students responded to some questions related to the process of digestion, the importance of digestion, digestive organs and system with some information they found online, and they used “my theory” rather than “new information” as scaffold. Can you give some possible explanations for these alternative uses of scaffold?

Analyses

For each scaffold, we analyzed the content inside to understand if the writer(s) used the scaffold appropriately. Then we analyzed what scaffolds the students used over time after correcting incorrectly used ones and adding blank ones. Thematic analysis was conducted to identify idea threads from all the notes contributed by the students to explore how scaffold usage influenced students’ theory building. An idea thread is a conceptual thread of notes which aims to address the same principal issue (Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007). Then notes in each thread were coded using a modified version of content analysis coding framework (Yang, van Aalst, Chan, & Tian, 2016). Modifications were made to the coding framework to highlight “improved explanation” and to distinguish it from “explanation” and to analyze students’ ability to integrate information sources from textbooks or from the internet to help explain questions. The modified coding framework includes four categories and related sub-categories: questions (fact-seeking question, explanation-seeking question), ideas (simple claim/appraisal/paraphrase, partial explanations or elaboration request, explanations, improved explanation), information (direct introducing, paraphrase of online information) and community (synthesis and regulation). A thread would be considered productive if there is any occurrence of “improved explanation” coding inside. Otherwise, it would be considered as a thread that needs further improvement (Chen, Resendes, Chai, & Hong, 2017). The teacher’s reflection was analyzed and summarized to describe what kind of support she provided to the students regarding scaffold usage, and how she understood why the students used scaffolds in a certain manner.

Results

Appropriateness of scaffold usage

117 out of the 217 notes contained scaffolds, and 23 of them contained two scaffolds. Therefore, there were 140 scaffolds in total. The teacher and students had customized and created their own scaffolds such as “my question is” and “I wonder why” and used them with default scaffolds such as “I need to understand” (as shown in Table 1). We combined scaffolds that served similar purposes and categorized them as questions, my theory/idea, information, further explanation needed, synthesis, a better theory, I am shocked, and I learnt. The frequency of different scaffolds used in all the notes before and after combination is shown in Table 1. The analyses revealed that students proposed a lot of questions, responded to the questions with their theories as well as with information they found online, but they rarely used theory refinement scaffolds such as “this theory cannot explain”, “putting our knowledge together” or “a better theory”.

Table 1. The frequency of scaffolds used by the community and the frequency after combining similar scaffolds

Scaffolds	Frequency	Combining similar scaffolds
I need to understand	45	
My questions is	5	Questions (54)
I wonder why	4	
My idea is	3	
My theory	26	My theory/idea (29)
New information	37	
What I found online	1	Information (42)

New information I found	4	
Can you explain further	1	
This idea cannot explain	1	
This theory cannot explain	5	Further explanation needed (7)
Put our knowledge together	4	
Combining our ideas	1	Synthesis (5)
A better theory	1	A better theory (1)
I am shocked	1	I am shocked (1)
I learned	1	I learned (1)

Table 2. The frequency of scaffolds not used appropriately

Scaffolds used not as designed purpose	Frequency
This theory cannot explain	4
Putting our knowledge together	2
Combining our ideas	1
My idea is	1
New Information	1
My theory	5

Among the 140 scaffolds, 14 were not used aligned with the designed purposes (Table 2). For instance, in four notes, the students did not build on any theories when using “this theory cannot explain”, rather, they asked new questions. In three of the notes, the students provided their theories or new information when using “putting our knowledge together” or “combining our ideas.” In a note used “new information” as the scaffold but asked an explanation-seeking question. Also, in six of the notes, the students wrote what they had learnt from the videos posted by the teacher or introduced related online information but used “my theory” or “my idea is.” The results indicate the students had more problems in using theory refinement scaffolds such as “this theory cannot explain”, “putting our knowledge together”, “combining our ideas” – which are also the scaffolds used less frequently by them, and they might consider information they found online as their theories/ideas.

After correcting the scaffolds that were not appropriately used and adding appropriate scaffolds to the notes without scaffolds, we drew the distribution of scaffolds over time (as shown in Figure 1). The community proposed a lot of questions in the first session, then gradually built knowledge with theories and new information. However, students did not question the proposed theories, nor did they synthesize different theories or provide better theories in a satisfying frequency.

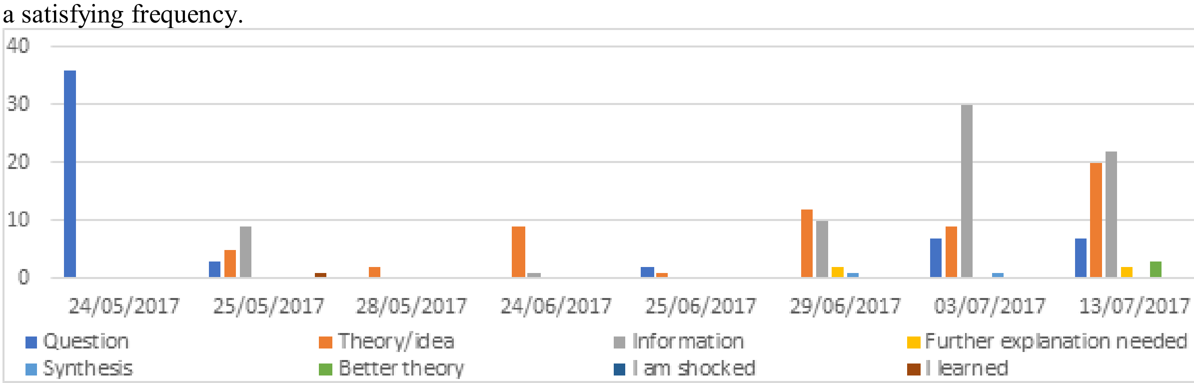

Figure 1. The scaffolds indicated in students’ notes over time after correcting wrong ones and adding blank ones

Scaffold usage and idea improvement

All the 217 notes were classified into eight inquiry threads. Three threads were identified as productive ones, which were about digestive organs and system, the process of digestion, and eating cooked/raw food. In the digestive organs and system thread, 28 out of the 65 notes contained scaffolds, including “I need to understand”, “my question is”, “I wonder why”, “my theory”, “this theory cannot explain”, “put our knowledge together” and some similar ones. However, “this theory cannot explain” and “put our knowledge together” were not used appropriately. In the thread of the process of digestion, 25 out of the 47 notes contained scaffolds such as “I need to understand”, “this theory cannot explain”, “put our knowledge together”, “new information”, “what I found online”, “from the internet”, “I learned” and so forth. Similarly, “this theory cannot explain” and “put our knowledge together” were not used appropriately. In the eat cooked food thread, the teacher and students used scaffolds in 22 of the 30 notes; the scaffolds they used were: “I need to understand”, “my idea is”, “my theory”, “new information”, “can you explain further”, “a better theory”, “I am shocked”, “put our knowledge together”; and most of the scaffolds were used appropriately, even the rarely used ones.

One example of productive threads is: S23 initiated the thread “eating cooked/raw food” by asking “*I need to understand why must we eat steaks and chicken which are cooked and not raw*”, S25, S18, S14 responded it was because “*raw food have many bacteria*”, “*cooked food is easier to digest*”, “*raw food need to be cooked so that the bacteria on the food will be break down*” and “*raw food does not taste good and it got (gets) some stinky smell*.” S1 improved the explanations by responding “*Putting our knowledge together - Raw meat can make people ill if the meat is contaminated with bacteria. If we were to kill an animal and immediately consume its flesh without storing it, we would not get sick. But in modern meat processing plants, the meat can become contaminated with faecal matter from the hapless animal; the same goes with eggs from factory farms. So it is best to cook meat and eggs, rather than eating them raw, not just for digestibility but also to kill the bacteria*”, and S26 added “*A better theory - our immune system may not be strong enough to defend our body against bacteria from raw and uncooked products*.”

Five of the threads needed further improvement: the importance of digestion, what are enzymes, enzymes have active sites, enzymes are specific, and enzymes are recycled. In the “importance of digestion” thread, 9 out of the12 notes contained scaffolds such as “I need to understand”, “my idea is”, “my theory”, and “new information I found.” In the thread of “what are enzymes”, scaffolds such as “I need to understand”, “new information”, and “my theory” were used in 9 of the 14 notes. In the “enzymes have active sites” threads, the students used “I need to understand”, “new information”, and “my theory” in 7 of the 13 notes. In the thread of “enzymes are specific”, 11 of the 19 notes contained scaffolds such as “I need to understand”, “my idea is”, “my theory”, “new information” and “put our knowledge together”. Among them, “put our knowledge together” was not used aligned with the design intention. And in the “enzymes are recycled” thread, the students used “I need to understand”, “new information”, and “combining our ideas” in 6 out of the 17 notes. However, “combining our ideas” was not used appropriately.

Regarding the threads that need further improvement, the “what are enzymes” thread began with two questions “*Where and why are the enzymes located where they are*” and “*How do you affect the activity of enzymes*” generated by the teacher. The students responded to the questions by providing information they found online such as “*temperature, pH, substrate concentration and the presence of any inhibitors or activators*” and partially explanation like “*Salivary glands (Mouth), Secretion glands (Stomach, Pancreas, small intestine). I'll leave why for others to elaborate.*” Regarding the “enzymes have active sites”, “enzymes are specific” and “enzymes are recycled” threads, the teacher posted several YouTube videos to start the conversation. The students mainly built on the videos with what they had learnt from the videos or found online, for example, “*enzymes are protein folded into complex shapes that allow smaller molecules to fit into them. The place where the substrate molecules fit is called the active site*” and “*enzymes are specific both in the reactions that they cause and in their choice of reactants, which are called substrates. An enzyme usually causes a single chemical reaction or a set of closely related reactions*.”

By looking at the aforementioned examples, we found that there tended to be more notes in the productive threads than in the threads that need further improvement. Also, in the productive threads, more diverse scaffolds were used, including theory refinement scaffolds such as “this theory cannot explain”, “putting our knowledge together”, and “combining our ideas”. However, in the threads that need further improvement, mainly commonly used scaffolds such as “I need to understand”, “my idea is”, “my theory”, and “new information” were used. Although some advanced scaffolds were used in the threads that need further improvement, they were not used appropriately.

Teacher’s Role and Support

The teacher’s design was to explore digestion with the students in the first month and to extend their knowledge in the second month. She aimed to help the students apply textbook knowledge to authentic questions/issues they had and to extend their understanding of digestion by working in the community. The teacher believed she must move away from overemphasis on content acquisition to students’ process skills and attitudes in order to develop scientific literacy. She considered Knowledge Building as a pedagogy and Knowledge Forum as a platform to move towards collaborative and learner-centred education. The Knowledge Building principles she mainly focused on were *idea diversity, improvable ideas, real ideas/authentic problems* and *rise-above*.

The teacher asked the students to start their Knowledge Building discourse on digestion by writing three words associated with digestion, two questions they had and a metaphor they associated digestion with. In the Knowledge Building process, the teacher highly encouraged her students to use scaffolds as she believed the scaffolds would help them think. In class, she explained how and when to use the scaffolds, for example, she introduced that scaffolds such as “My theory” and “I need to understand” might help generate diverse ideas while scaffolds like “A better theory”, and “This Theory cannot explain” might help refine theories. The teacher and students also customized scaffolds to make them easier to comprehend and to use since the students found the existing scaffolds were not easy to construct into sentences. At the end, the teacher asked the students to do a paper-based reflection on how the study of digestion had helped them to understand their body.

Regarding why the students mainly used scaffolds like “my theory”, “new information”, the teacher indicated a possible reason is that the students found “my theory” and “new information” to be safe to use and they might not be confident to improve or challenge their peers’ theories. She explained this could be from the traditional way the students had been taught – there were only right or wrong answers. And the concepts of improvable idea, community knowledge and collective responsibility were still very new to the students. Through content analysis of the notes, we found that the students mainly copied or paraphrased online information to respond to the questions in the community. Sometimes, the information they found online well fit the questions so that it could explain the reasons, relationships or mechanisms requested in the questions, indicating students’ ability to locate and use authoritative sources to explain their wonderings. This phenomenon might have something to do with the teacher’s design since she indicated that “*This is lesson I would like students to develop (Scientific skills and thinking) - use the textbook knowledge and apply them to related and authentic issue/extend their learning/collaborate with other students to build their extension of learning.*”

Regarding the inappropriate use of scaffolds, the teacher reflected that some of the students did not take the scaffolds seriously and just chose a scaffold without much thought of the appropriateness, and some might be unclear about the appropriateness of the scaffolds, or they might not understand the demand of the scaffolds. Therefore, more guidance from the teacher on the use of the scaffolds may help.

Conclusions and Discussions

These results indicated that the students mainly used question, my theory/idea and information related scaffolds. Overall, the students had no problem using the theory development scaffolds, but they rarely used theory refinement scaffolds, nor could they use the theory refinement scaffolds appropriately. In productive threads, the teacher and students tended to use theory refinement scaffolds such as “this theory cannot explain”, “putting our knowledge together” or “a better theory” while in the threads that need further improvement, they seldom used them.

The students mainly copied or paraphrased online information to respond to the questions in the community. Sometimes, the information they found online well fit the questions so that it could explain the reasons, relationships or mechanisms requested in the questions, indicating students’ ability to locate and use authoritative sources to explain their wonderings. This is a phenomenon consistent with what Scardamalia and Bereiter (2006) found in a Grade 3 class where the students used “did you know” a lot to do “knowledge telling” by introducing information they found online or from textbooks. The difference may be that in this study, the students tried to locate information to respond to some existing questions while in Scardamalia and Bereiter’s (2006) study, the students just recorded what they found interesting. However, in the Grade 3, the students were able to figure out that they used “did you know” too much and decided to introduce new scaffolds to move from knowledge telling to Knowledge Building through a meta-discourse. A meta-discourse in this study might help the teacher and students to reflect on their contributions and the gap between what they were doing and their goals.

How a note was posted influenced how students built on it. For example, if a note only contained a video link, the students tended to directly build on it with knowledge they learnt from the video or found online. In this way, they rarely interacted with each other’s ideas or improve community ideas. The reason may be that there were no authentic questions for the students to explore or to respond to. On the other hand, when some authentic questions were asked, students tended to connect the questions with their life and go deeper. For example, the teacher reflected that the students “*have a lot of questions that are out of the textbook, e.g., farting, acid reflux. They seem to be trying to link the topic to authentic issues they have experienced before.*” We also noticed that when the students worked on these authentic issues, they were more likely to write what they thought rather than directly introducing online information and tended to improve their explanations to the questions.

In addition, the results indicated that the students need help to go beyond working with authentic ideas, information and theories and need to make efforts to improve their community ideas. Some previous studies (e.g., Chuy et al., 2010; Zhang et al., 2007) showed evidence that the use of theory-refinement scaffolds such as "Our improved theory", "I disagree, because…", "What's your evidence?", and "Can you think of a way to test your theory?" resulted in productive interactions that contributed to the scientific and theoretical progress of the discourse. The result is also consistent with Shabo, Guzdial, and Stasko's (1997) study, which suggested that students hesitate to use scaffolds when they have problems in interpreting scaffolds, and with Sharma and Hannafin's (2005) study which indicated that instructions are needed to help students use scaffolds appropriately. In the teacher's reflection, she indicated that the class had no issues with idea diversity. However, the kids were cautious to move into areas such as relating what they learnt to real-world issues, connecting their ideas and synthesizing new knowledge. The students did attempt, but they needed more time to move into these areas. Unfortunately, the curriculum did not allow for the luxury of time. What is promising is that the teacher understood that deep learning goes beyond covering the subject-instructional objectives defined in the curriculum document. She saw the need to guide students through a continuous process in order to develop the aforementioned capacity. She continues to forge a concerted and consistent efforts from teachers in her team to create such space and experience for students.

In this study, we mainly analyzed the scaffolds used in students' notes, the content of the notes and the teachers' reflection of scaffold usage. One implication of this study is that working on authentics questions that students care about helps students contribute and improve theories rather than just finding information online to respond to the questions. Another implication is that teachers should help students to understand and use theory refinement scaffolds since when found that when the students used theory refinement scaffolds appropriately, they usually made productive threads. However, the students rarely used theory refinement scaffolds or do did not use them appropriately. The scaffolds may also need to be better designed to make them more understandable and more accessible for the children. Understanding how students perceive Knowledge Building scaffolds and how to support them in scaffolds usage may foster community knowledge advancement. Our next step will be interviewing students to understand their perception of scaffold usage and engaging them into meta-discourse of scaffold usage to enhance idea improvement.

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Short Papers

The Impact of Brokers towards Students' Knowledge Growth in Knowledge Building

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Abstract: Promoting knowledge growth of the whole community is the key to knowledge building, during which will generate various peer roles. Broker is one of the peer roles that does not belong to this group, but attract this group members even others to interact with, which may make information exchange easier. So in order to figure out whether broker will influence students' knowledge growth and what impacts will it have in knowledge building, the research was conducted in a first-year master student class with 24 students in total where naturally generated 10 brokers that can be identified via the interaction relation matrixes. And all data includes students' contributions and their contents of ideas are all from Shuke platform. Then we automatically got keywords of brokers' notes by TextRank algorithm. And verified direct relevance between group members' and brokers' ideas using KBDeX. Content analysis is used to figure out what students' inquiry focuses and threads are. The research results indicated that as for broker, it is much easier to be accepted and developed to provide starting ideas; but the utilities of brokers are more likely to remain in the initial phase of knowledge building. And brokers will influence students' knowledge growth to some degree, especially when brokers' ideas are developed by opinion leader will make a strong impact towards students' knowledge growth, but broker is not the only factor influence students' knowledge growth. More brokers sometimes don't mean high speed of knowledge growth, which is influenced by the degree of difficulty of the topic a group is discussing.

Introduction

Knowledge building theory considers knowledge creation as a social product (Bereiter, 2002), therefore, it emphasis a distributed social structure in knowledge creation organization. So it is quite common to have group collaboration in knowledge building, where different peer roles will be generated naturally. Zhang's research (2009) showed that opportunistic collaboration in knowledge building will help students to have high collaborative responsibilities and knowledge advancement. In opportunistic collaboration, groups are tend to form and disband under the volition of community members, students are regardless of which group belonged to. So for the purpose of knowledge advancement and growth, how to help students to blur the boundaries among groups? Sarmiento & Shumar (2010) suggested building collaborative knowledge relies precisely on the successful engagement of multiple roles over time, and roles that participants enact while engaged in collaboration is a central element of how interaction get shaped, which is important to knowledge growth in knowledge building.

And Two-Step Flow of Communication (Rogers, 1995) also provides an idea that the formation of human's ideas and attitudes will be influenced by others around. Numbers of researches put efforts on the impact of Opinion Leader (Lazarsfeld & Kats) who is held in high esteem by those who accept their opinions. But actually the role that makes isolated group together is not opinion leader but broker (Burt, 1992; Marsden,1982,p.202; Stadtler, L., & Probst, G.,2011）. Broker is a kind of role that seems to be ignored in knowledge building and is popular in the marketing and management field, which was defined as an independent party, whose prime responsibility is to bring sellers and buyers together and thus a broker is the third-person facilitate between a buyer and a seller. In sociology field, a broker' function is familiar, which can broke the boundaries of groups and makes the information exchange easier just like a bridge, in other word, broker is a go-between. As for in knowledge building community, broker is independent, which means it does not belong to this group but it still attract others to interact in this group which connect isolated group together, make the whole community knowledge together.

And knowledge growth, as an important indicator in knowledge building, can be identified with the growth of the content of theories (Popper, 2002). There are various ways to measure knowledge growth. Some captured learners' discussions, conversations and e-mail correspondences to point to the joint development of new knowledge (Karsenty, Arcavi, et al, 2015); some used the progress test to assess knowledge growth (Schaap, Schmidt, Verkoeijen, 2012); some coded the interview and observational data and use content analysis to measure knowledge growth (Grossman, Richert, 1988). And in Jin, Zhang and Sun's research (2014), it manifested that students' contributions, like asking questions, using scaffoldings… were related to students' knowledge growth, which could indirectly describe knowledge growth. From all these, measuring knowledge growth is about direct and indirect aspects. In this research, students' contributions are considered to be a relevant indicator for students' knowledge growth, and their idea contents are another important and direct indicator.

And after a period of time observing in the experimental class, students started to read and develop other groups' ideas, even posed their own ideas in other groups step by step. And the roles broker and opinion leader were generated during the whole knowledge building process naturally. At that time, students' knowledge growth was increased significantly from their idea contents and contributions. So an assumption was made that brokers could help students' knowledge growth, but how they influence students' ideas development? Therefore, there are 4 problems need to be solved in this research:

1. How to identify broker?
2. How to measure knowledge growth from indirect aspect?
3. How to verify relevance of notes between brokers and other students?
4. How to measure knowledge growth from direct aspect?

So in the remaining sections we try to solve these four problems. First we use social network methods to identify broker, then quantity analysis is needed to measure students' knowledge growth when brokers appear from indirect aspect, which will collect students' online contributions. Secondly KBDeX and TextRank algorithm is used to verify their connections, and finally content analysis is used to measure students' knowledge growth from direct aspect.

Methods

Research Design

1. Participants and Curriculum Settings

The experiment was completed among 24 master students of first year (s1, s2…S24), majored in modern educational technology who were never been taught using knowledge building theory before. Learning science was the experimental curriculum that used the knowledge building theory as guidance for once a week, totally 12 weeks and was given by an experienced professor who was specialized in knowledge building. All the students were divided into 7 groups (G1, G2…G7), which were all defined by themselves. (See table 1).

Table 1: Students' group arrangement.

Group	G1	G 2	G 3	G4	G5	G6	G7
Students	s1, s5, s17, s21, s24	s3, s16, s18	s4, s14, s19, s23	s8, s10, s13	s9, s11, s22	s2, s7, s15	s6, s12, s20

2. Environment and Tools

In the relaxing class environment, students could leave seats to join discussions. Laptops were equipped for everyone. They used Shuke (www.91shuke.com) as an online discussing platform to support students' idea proposing, developing and rising above. Shuke can visualized students' thinking process, which is familiar with Knowledge Forum. On the meantime, students were encouraged to put their discussion ideas online in order to preserve and manage students' knowledge, which also convenient for getting research data.

Research Procedures

1. Identify Brokers and Opinion Leaders

Brokers need to meet with two features according to the definition. First, they are not this group members; second, their ideas can attract other group members to interact with. Therefore, those who provide ideas in other groups but cannot be got attention are excluded. So we collected students' interaction relationship on Shuke, including the number of idea developments, readings, collections, supports and comments, and made socio-matrixes. We drew yellow lines on the group members, so those who were out of the lines were brokers. (See figure 1 as an example).

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22	S23	S24
S1		1			15	1	6	1	2	4	5			1		8	14	4	7	3	17	1		23
S2																								
S3																								
S4																								
S5	21	1				1				2	1					1	6	5	1		3			17
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S17	9	4			5	1	1		1									1	3		9			11
S18							1		1															1
S19																								
S20																								
S21	16				7		5	2		2						1	9	3	5	1				12
S22																								
S23																								
S24	6				5				1	2	1					2	4		1	4	7			

Figure 1. Interaction relation matrix in G1

To be more specific, the interacting direction was from each column to each row. All the number in the cell represented the interaction frequency. In group 1 (G1), s1, s5, s17, s21 and s24 were group members, so all the number on the yellow line means inner group interaction or other group members interact with G1 members. And those numbers that were out of the lines means the influences that brokers made. Therefore, s16 and s18 were brokers in G1. We use the same method to get all brokers in each group (See table 2).

And we use UCINET to calculate the degree centrality which was used to find the central people in a group to identify the opinion leaders (see table 2). Those kind of people is considered to be the most important person from the perspective of sociology.

Table 2: Brokers and opinion leaders in each group

Group	Brokers	Opinion Leader
G1	s16, s18	s1
G2	s1, s5, s8	s16
G3	s1, s7, s8, s16	s4
G4	s5, s14, s16, s17, s19	s8
G5	s1, s8, s16, s17, s18	s11
G6	none	s7
G7	s1, s7, s15	s12

2. Measure Knowledge Growth from Indirect Aspect

This research tried to calculate students' contributions on Shuke to indirectly demonstrate their knowledge growth, which has already been proved that students' contributions are closely related to their knowledge growth (Jin, et al, 2014). Overall, in order to present each students' contribution increases, three contiguous time intervals that are before and after broker's appearance need to be identified.

So first of all, the time point when broker appeared would be identified as P (see figure 2). Then we take two weeks as a suitable time span, so three contiguous time intervals are respectively (1) start from four weeks before broker's appearance to the following two weeks, i.e., [P-28, P-15]; (2) start from two weeks before broker's appearance to the following two weeks, i.e., [P-14, P-1]; (3) start from the time broker's appearance to the following two weeks, i.e.,[P, P+13]. To be clearer, see figure 2.

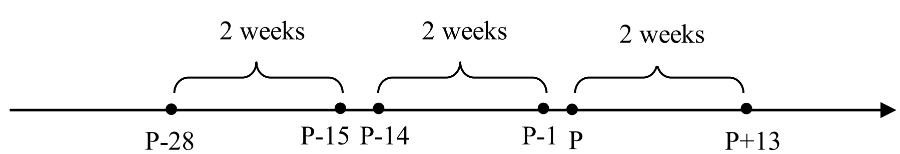

Figure 2. Illustration of the three periods

Secondly, students' contributions on Shuke of each period ([P-28, P-15] as period 1; [P-14, P-1] as period 2; [P, P+13] as period 3) were summed up respectively, which included the number of students' opinion posting, developing, rising above, collecting, updating, commenting, reading, supporting and use the keywords and scaffoldings. Then for the purpose of analyzing their increases of contributions, we consider the contributions in period 2 minus the contributions in period 1 to roughly measure the knowledge growth in the first phase; the contributions in period 3 minus the contributions in period 2 to roughly measure the knowledge growth in the second phase to see the contribution growth in two different phases.

3. Verify the Direct Relevance of Ideas among Brokers and Group Members

KBDeX is a tool to explore and visualize the discourse network structure based on keywords and discourse unit (e.g., conversation turns, postings on an online forum, and sentences), developed by Yoshiaki Matsuzawa and Oshima's team. In this research, discourse unit is each student's postings. The notes that represent discourse unit are connected by lines if they share at least one selected keywords. Therefore, it can present a network structure of notes which means the co-occurrence of keywords. So here, KBDeX is used to verify the direct relevance of ideas among brokers and group members. There are two indicators, (1) Whether brokers and students' idea share same keywords; (2) Whether students' notes are closely connected. Because the connection is based on the keywords, if different notes have at least one same keywords, then there is a connection, which means students' discussions are closely about brokers' ideas.

Below is a general idea of how to verify the direct relevance (see figure 3). Brokers' idea keywords need to be identified at the first place. So their idea contents on Shuke are collected and we use the TextRank algorithm implemented by Python to get the keywords of brokers' ideas automatically because getting keywords manually can be subjective. Then we got all students' idea contents on Shuke and rearrange them as excel file and replace the data file in KBDeX. Then we chose brokers' idea keywords from students' notes to see whether they share the same keywords, and on the other hand, to see the network structure of notes, which can verify the direct relevance of ideas among brokers and group members from the notes connection.

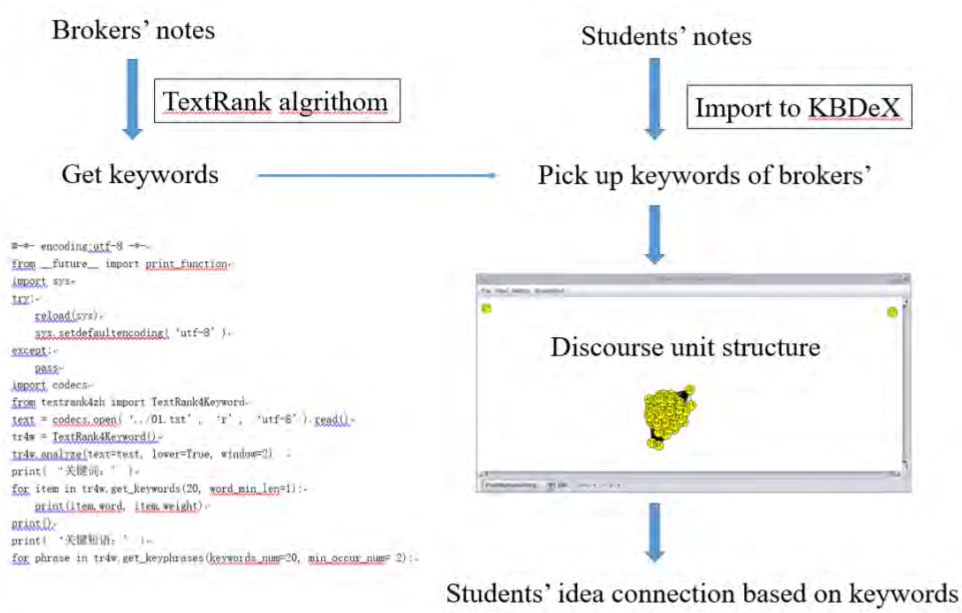

Figure 3. General idea of how to verify the direct relevance

4. Analyze the Quality of Knowledge Growth

As mentioned above, students' idea-contents are an important and direct indicator of knowledge growth. In Jin, Zhang and Sun's research (2014), it considered students' electronic learning portfolio as important data to judge students' knowledge growth, and use content analysis to analyze specific topics, focuses and inquiry threads. An inquiry thread can be defined as a series of notes that address a shared principal problem and constitute a conceptual stream in a community knowledge space (Zhang, Scardamalia, et al，2007), which is based on the content of students' notes. So in this research, there formed several inquiry threads in each group. In order to evaluate students' knowledge growth from the perspective of students' idea contents as well as to figure out the relation between group members' knowledge growth and brokers' idea, we tried to analyze students' inquiry threads to understand their knowledge growth.

Data Analysis

The Quantity of Students' Knowledge Growth

After calculating students' contributions growth on Shuke in two different phases, which can represented their involvement in knowledge building and could be indirectly indicated as knowledge growth. All results were visualized (see figure 4, figure5, figure 6, figure 7, figure 8, figure 9), while there are no brokers in G6. We totally found 10 brokers, and 18 students whose knowledge growth has been largely increased, totally 85.71% among all 21 students. So from the perspective of quantity analysis, we could say group members' knowledge growth was influenced by brokers in some degree.

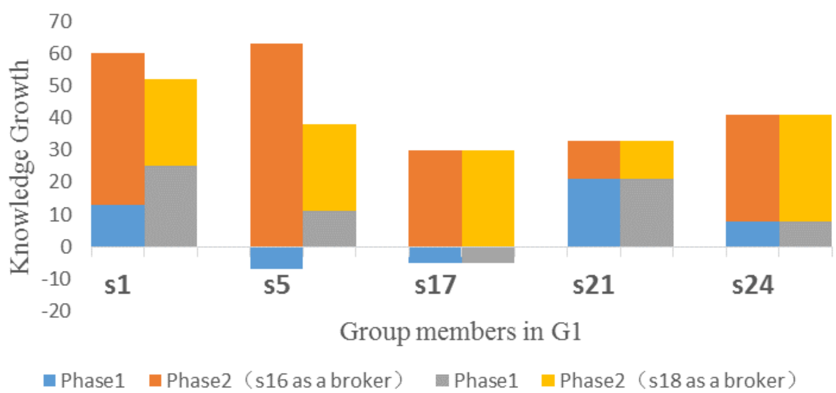

Figure 4. The knowledge growth before and after brokers' (s16, s18) presence in G1

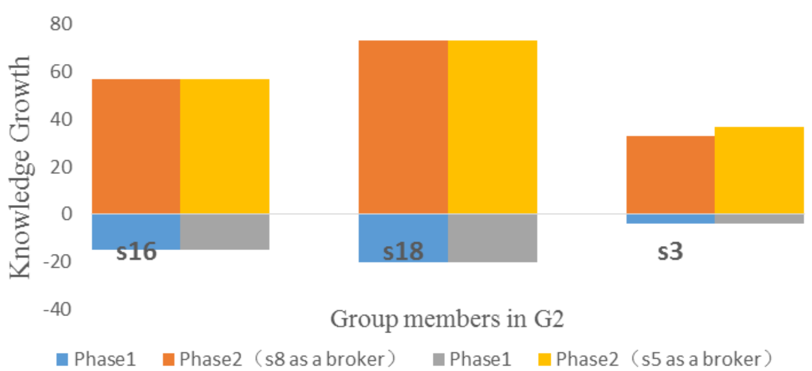

Figure 5. The knowledge growth before and after brokers' (s8, s5) presence in G2

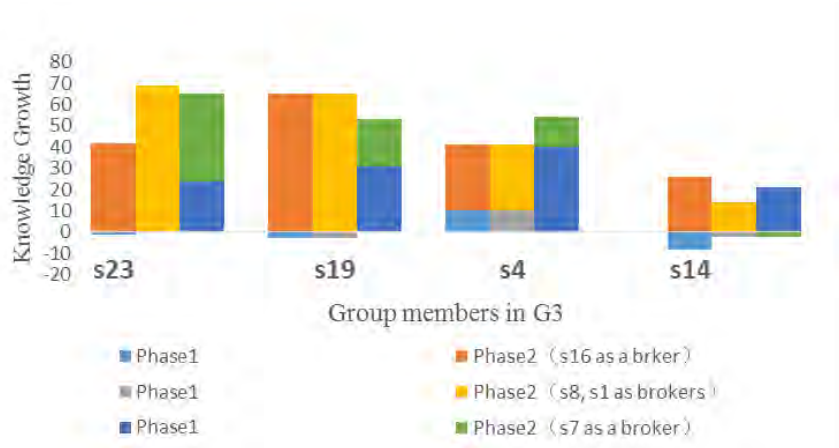

Figure 6. The knowledge growth before and after brokers' (s16, s8, s7) presence in G3

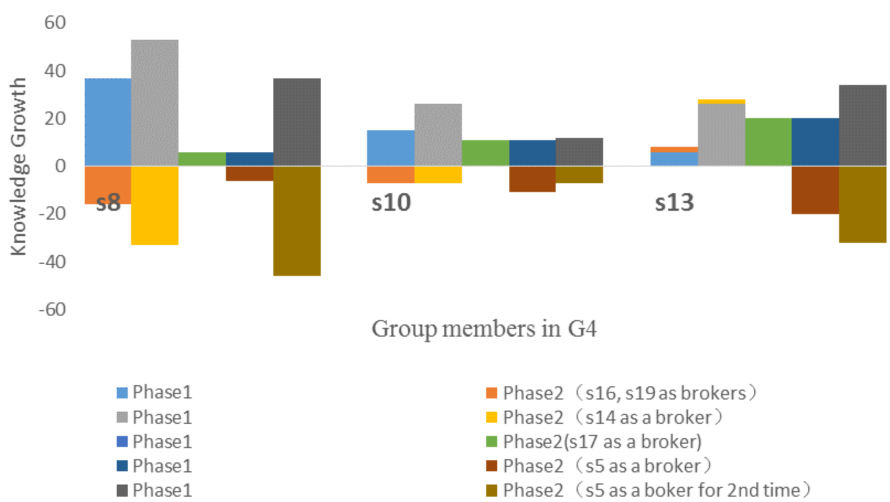

Figure 7. The knowledge growth before and after brokers' (s16, s19, s14, s17, s5) presence in G4

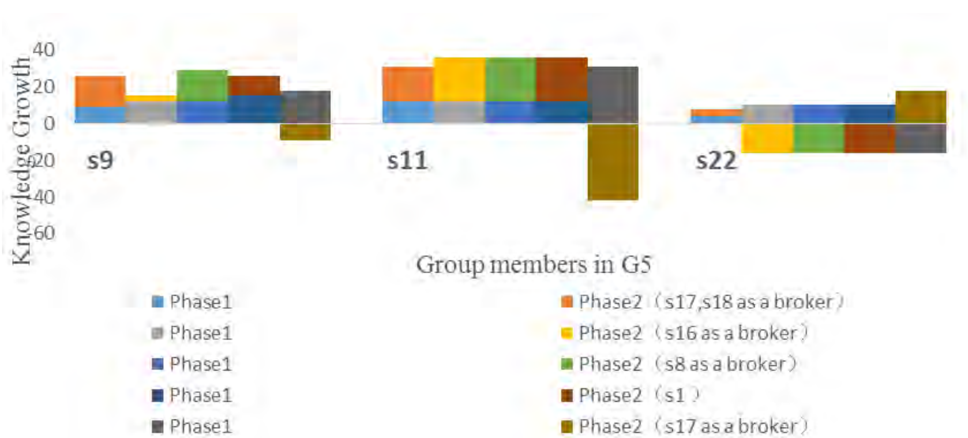

Figure 8. The knowledge growth before and after brokers' (s16, s17, s18, s8, s1) presence in G5

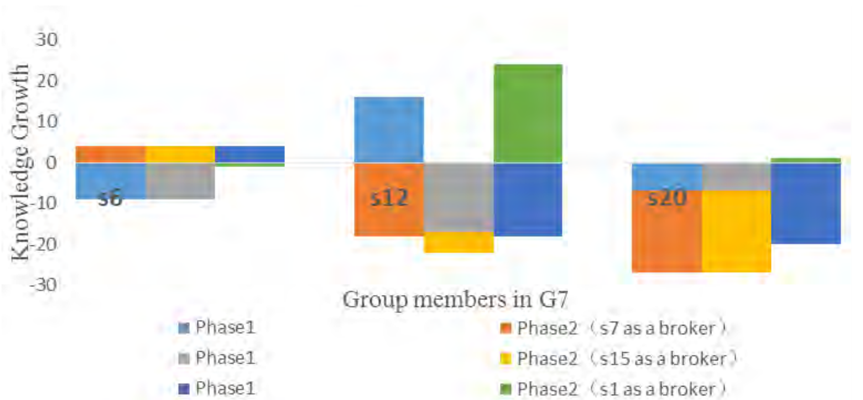

Figure 9. The knowledge growth before and after brokers' (s7, s15, s1) presence in G7

The Direct Relevance among Group Members' Knowledge Growth and Broker's Idea

We used the KBDeX to get the discourse unit relation structures based on keywords, and the research found that all groups' network structure of discourse unit are alike. So here G1 is considered as an example to analyze the discourse network structure (figure 10) and the summation of the degree centrality of the discourse unit network (figure 11).

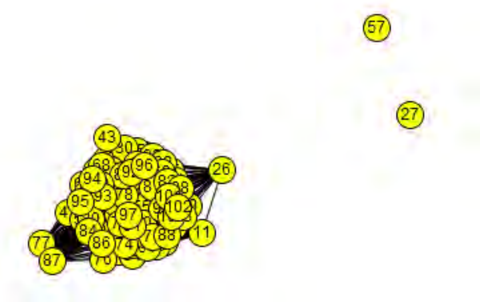

Figure 10. The network structure of discourse unit in G1

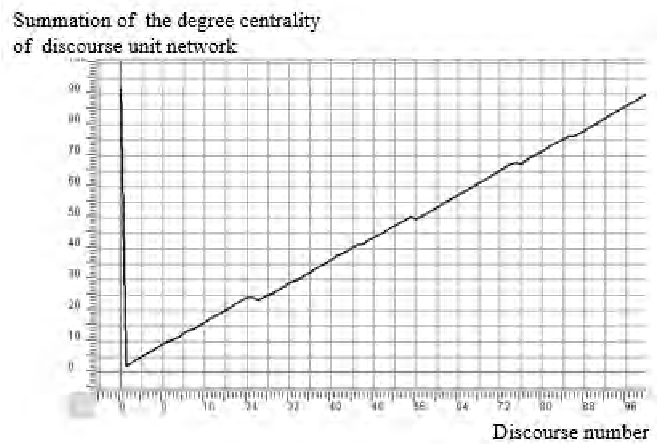

Figure 11. The summation of the degree centrality of the discourse unit network in G1

1. There were closely connections among students discourse unit, which indicated that the whole group's discussion was closely related to the keywords provided by brokers. In other words, there were overlaps among group members' ideas and brokers' ideas, which could indicate the direct relevance.

2. The summation of the degree centrality of the discourse unit network kept growing, which indicated each group were discussing about something that related to brokers' ideas continuously. So from those analysis, we could say group members' knowledge growth was potentially impacted by brokers.

The Quality of Students' Knowledge Growth

There were totally 46 inquiry threads in 7 groups. Several categories and sub-categories were under each inquiry thread. Here is a content analysis in in G1 as an example (See table 3). All the content has already translated into English. And table 4 shows the number of brokers and the number of inquiry threads.

We did correlation analysis between the number of brokers and the number of inquiry threads in each group, and it turned out that $r = 0.472$, which indicated moderate correlation. In other words, it means there had some correlation between students' idea threads development (knowledge growth) and the number of brokers, but there were so many factors that could impact students' knowledge growth, brokers' ideas were just one of the factors.

Table 3: Coding framework for content analysis of discourse in G1's inquiry thread

Inquiry thread	Categories	Sub-categories	Examples
1. System module	1.1 What is learning	1.1.1 Classification of	Divided by the learning content; Divided by the

And as for practice, increasing the communication among students is the basic teaching method, and just as mentioned above, the effect of knowledge growth would be better, if brokers and opinion leaders can work together. Therefore, teacher can ask brokers and opinion leaders to have a presentation in front of whole class. And teacher could make some requests for students' posting in other groups. On the one hand, students are requested to provide more ideas rather than answers, on the other hand, students are requested to focus on other groups' topics and ideas continuously, rather than staying in the initial stage. And finally, teacher needs to help students to understand some complex topic, provide scaffoldings and make rules for those groups that have easy topic, which will avoid some invalid group interactions.

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	platform	online learning platform	standards of the development and management department
		1.1.2(Topic changed) computer supported teaching platform	The applicable object differences between the learning platform and the teaching platform
			The applicable object differences between the learning platform and the teaching platform
			It is easier for teaching platform to find its features.

Table 4: The number of brokers and inquiry threads

Brokers	2	3	4	5	6	0	3
Inquiry threads	5	7	9	8	5	4	7

Through deep analysis of each group's idea threads, we found that:

1. There would be greater impact effects if brokers' idea was developed by opinion leaders

Most of the ideas provided by brokers would attract those group members to read, think and answer, which indicated the importance of brokers' ideas for group members. For example, in group 1 (G1), the idea provided by broker s16 was about the categories of learning platform which was later developed by G1's opinion leader, and then caused intense discussion in G1, even make the whole group to change their subtopic ---- from learning platform to computer supported teaching platform. So all this has indicated when broker and opinion leader work together, it would be better for the whole group's topic development.

2. It would be easily accepted and developed if brokers could provide some starting ideas

Some brokers provide the starting ideas of the whole inquiry thread while some brokers provide small focuses or even smaller sub-focuses. And it was hard to arouse extensive discussion and hard to develop a new inquiry thread when brokers' focus was small, which indicated those concrete idea such as some demos and examples provided by brokers were easily ignored. On the contrary, ideas and guidance were much needed for group members.

3. Brokers just showed up in the initial phase of knowledge building

All brokers just showed up in the initial phase of knowledge building, while in the end even the middle of this course, the interaction among students all just stayed in their own groups. The reasons were, the phenomenon of tiredness and bottleneck for knowledge building have appeared among students; on the other hand, students had no much time to read and develop other groups' ideas when the discussions were much deeper as time went by, which might mean students were more willing to think a group as a learning community rather than think the whole class as a learning community.

4. Groups without brokers have the least knowledge growth

In G6, there were no brokers, and not only the number of its idea threads which were 4, but also its sub-categories which were 39, were the least among all groups, which indicate the least knowledge growth.

5. Whether the discussion topic was easy or difficult was important for brokers to show up. Those groups that had many brokers did not mean knowledge growth were most quickly.

In G5, it had 6 brokers, while the number of its idea threads was only 5. But in G2, it had only 3 brokers, while it has 7 idea threads. The reason why the number of brokers was large but the number of idea threads was small was because the content G5 discussed was about personalized learning, which was easy and close to students' life, so the discussion might be shallow. While as for G2, their discussion was about learning analytics, involving lots of terminologies that were unfamiliar with students. Therefore the discussion could be sustained though the number of brokers was limited.

Discussion and Reflections

All in all, there were so many factors can influence students' knowledge growth. From the perspective of peer roles, brokers could definitely influence students' knowledge building in quantity and quality, making the whole community knowledge together and improving students' collective responsibilities, which was one of the principle of knowledge building. But in this research, because of the time limitation, 12 weeks were actually too short for students to be involved in knowledge building, therefore, the number of brokers were not enough.

So in the future, we first need to increase the teaching time in order to deepen students' discussion, which will be helpful to increase the number of brokers and enrich the dataset. Secondly, we are supposed to verify whether these rules are still useful among students that are in different ages.

Offline Group-level Knowledge Building Discourse in a Large Community

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Abstract: This study examined offline group discussions in two large communities. Students in Class A discussed face-to-face in the groups before the whole collective online interaction, whereas students in Class B conducted regular knowledge building discourse without groups. The data sources included audio recordings of group discussion and Knowledge Forum databases. Results found that students in Class A showed better collective knowledge advancement. However, unbalanced distribution of expertise in different groups was also observed. These findings inform future work in strategies design for more groups to engage in collaboration and cross-group interactions for sustaining knowledge building discourse in large community.

Introduction

Many researchers in the learning sciences studies collaborative inquiry, which have many benefits for learners, such as the development of collaboration skills, metacognition, and agency(Sawyer, 2006). However, the outcomes of collaborative inquiry depend on the quality of the social interaction involved (Barron, 2003; Stahl, 2006). Generally, small groups or small size classes (usually with 20-30 students) engage in high quality interactions, and large size groups (usually over 30 students) usually exhibit low level interaction without proper facilitating strategies. Research on collaborative inquiry showed that small-group practices such as face-to-face discussion and reflection could contribute to productive community-level interaction and knowledge creation (Resendes, Scardamalia, Bereiter, Chen, & Halewood, 2015)

Knowledge building, a community-oriented approach emphasizing collective cognitive responsibility for advancing knowledge (Scardamalia, 2002) and influential model in collaborative inquiry, is frequently used by teachers to engage students in collaborative knowledge building. Knowledge Forum(Scardamalia, 2004) is an online platform designed for creative community work where knowledge workers can post problems, construct explanations, test ideas, etc. It also provides the metacognitive scaffoldings to knowledge workers when writing their notes, such as *[My theory]*, *[I need to understand]*, *[Putting our ideas together]*, etc. Generally, most studies adopting knowledge-building pedagogy involve small-size classes of 15 to 30 students (Chen, Scardamalia, & Bereiter, 2015; van Aalst & Truong, 2011; Yang, van Aalst, Chan, & Tian, 2016; Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007). Very few studies involve large-size classes with more than 50 students.

In Asian countries, especially Mainland China, classes are generally with 50-60 students. How to promote large-size classes engaging in productive knowledge building is really challenging. To involve students in the advancement of community knowledge, we designed a knowledge-building environment augmented by the offline small group discussion and reflection. The study aimed to investigate the effects of the offline group discussion and reflection in facilitating collective knowledge among Grade Four students in science. The following research questions were investigated:

1. What was the nature of discourse generated in the offline group discussion?
2. To what extent did the group-level offline discussion facilitate collective knowledge?

Method

Classroom contexts and designs

This study was carried out in two Grade Four classrooms from a primary school in Mainland China, with 54 students in Class A and 53 in Class B respectively. The first author of this paper was also the science teacher. These two classes investigated the topic of *Force & Motion* with the support of Knowledge Forum during about nine weeks, with 1.5 hours' science lesson each week. Students first created a large number of notes on Knowledge Forum, and then they classified those massive notes into seven sub-topics with the teacher's facilitation. Those subtopics are: *Life and Motion* (T1), *Motion Speed* (T2), Motion Mode (T3), Relative Motion (T4), *Relationships between Force and Motion* (T5), *Types of Forces* (T6) and *Spring Balance* (T7). Later, the teacher created seven views for those subtopics and put students' notes into relative views. Students were encouraged to contribute to different subtopics. Especially, we implemented the offline group discussion into regular knowledge-building discourse in Class A. This intervention was a 15-minute collaborative group discussion, which was followed by interacting with the whole community on Knowledge Forum (see Figure 1). Students in Class A were divided into 13 groups with four or five students. They first reflected on their individual paper-version notes in their groups and created a group-level note, and then interacted with the whole community on Knowledge Forum individually. Those paper notes were similar to Knowledge Forum notes: students were encouraged to use scaffolds, such as *[My idea]*, *[I need to understand]*, *[putting our ideas together]*, etc. The group notes as artefacts were considered as the pioneering momentums for driving collective knowledge advancement. As a comparison, Class B conducted Knowledge Forum activities without such group discussions.

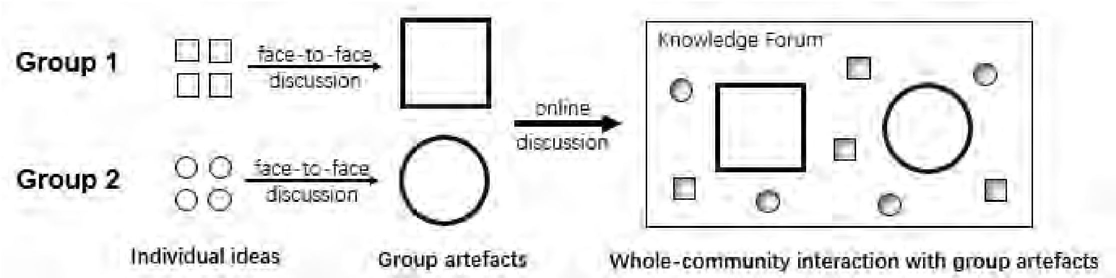

Figure 1. The intervention of offline group discussion in Class A

Data sources and analysis

To address the first research question, we collected 46 students' individual paper-version notes, 13 group artefacts, as well as 13 audio recordings of the group discussion. The audio records captured the first group discussion of Class A, in which students reflected their individual notes and integrated those notes into one group note. We performed qualitative analysis of the group discussion to understand the nature of students' group discussions of Class A. We read and re-read the transcriptions and identified some processes of the group discussion: students first reviewed and reflected their individual ideas after comparing them with those of their group members, then they tried to rise above individual ideas to a shared group knowledge and initiated to collect data for the new group knowledge. For some groups which did not know how to structure all individual notes into one would discuss why they failed in their discussion. To improve the external validity, we presented it to other teachers and researchers.

To address the second research question, we collected 463 Knowledge Forum online notes from Class A and 356 from Class B. We used several social network analysis tools to visualize students' collective knowledge advancement. First, we used KBDex (Oshima, Oshima, & Matsuzawa, 2012) to identify key words in the two communities. The first author and another science-background Ph.D. researcher selected 103 words from the domain of *Force & Motion* according to the 819 online notes from both classes. The agreement between two independent words' raters was 79.1%, and their disagreements were resolved through discussion. Then we adopted UpsetR (Lex, Gehlenborg, Strobelt, Vuillemot, & Pfister, 2014) to compare intersecting words among the seven subtopics in Class A and B. Finally, we used KBDex to compare word networks in different groups of Class A to investigate differences among groups in collective knowledge advancement.

Results

RQ1. What was the nature of discourse generated in offline group discussion?

This question was explored through tracing audio transcriptions of student offline group discussions. During the first discussion, students in Class A first worked on their individual ideas in the offline groups to create a group-level Knowledge Forum note, and then conducted the whole-community activities on Knowledge Forum (see Table 1.). Although they talked about the common topic *Force & Motion*, students in different groups showed different interests: six groups focused on *Life and Motion*, three groups focused on *Motion Speed*, two groups focused on *Mode of Motion*, one group focused on *Relative Motion*, and one group focused on *Relationships between Force and Motion*. Qualitative analysis of the group discussion in Class A identified the following processed in the group-level meta-discourse.

Table 1: Students' individual notes and group artefacts of Group 2, Group 3 and Group 7

Group	Student	Individual notes	Group artefacts
# 2	c524	N/A	*[My idea]* Motion mode includes linear motion, curved motion and curvilinear motion. There is no connection between motion mode and motion speed. *[I need to understand]* If we exert the same force to an object to make it move linearly or curvilinearly, which will be faster?
	c538	*[My idea]* There are two kinds of motion modes: linear motion and curvilinear motion. *[I need to understand]* Is the motion mode related to motion speed?	
	c539	*[My idea]* Motion mode includes linear motion, curved motion and curvilinear motion. *[I need to understand]* How many kinds of motion modes do human have?	
	c519	N/A	
# 3	c507	*[My idea]* Motion mode includes linear motion and curved motion. If an object is moving in a curve while doing a linear motion at the same time, this is a curvilinear motion. *[I need to understand]* What factors will affect the motion speed?	*[My idea]* Motion mode includes linear motion, curved motion and curvilinear motion. *[I need to understand]* What factors will affect people's walking speed?
	c531	*[My idea]* Motion mode includes linear motion and curved motion. We need a reference to judge whether an object is moving. *[I need to understand]* What animal has the fastest running speed in the world?	
	c513	*[My idea]* Motion mode includes linear motion, curved motion and curvilinear motion.	

		[I need to understand] What factors will affect people's walking speed?	
	c542	*[My idea]* Motion mode includes linear motion and curved motion. *[I need to understand]* Will we get the same result if we choose different references to judge whether an object is moving?	
# 7	c541	*[My idea]* If there is a reference, we can find an evidence of what is moving. *[I need to understand]* Can we find that whether we are moving if there is no reference?	*[My idea]* A car's speed will be affected by air resistance, friction and inertia. *[I need to understand]* What is the car's speed when the road condition is very bad in the thin/thick air?
	c520	*[My idea]* A car's speed will be affected by air resistance, friction and inertia. *[I need to understand]* What is the difference between the speed of the car in the thin air and the thick car?	
	c504	*[My idea]* The heavier the object, the slower its speed; the lighter the object, the faster its speed. The condition of the road will also affect the speed. *[I need to understand]* What is the speed when the object is light, but the road condition is very bad?	
	c535	*[My idea]* Exercise can slow aging, enhance physical strength, flexibility. It is important to maintain the health of bones and muscles, because they can work together to help moving. To judge whether an object is moving requires a standard, we call this standard "reference". *[I need to understand]* How do bones and muscles work together?	

Note. Students wrote their paper-version individual notes in the previous science lesson. Student c524 lose his paper note while student c519 did not come to the previous lesson.

Reviewing individual ideas and reflecting on their own ideas

Students were asked to read their own paper-version individual notes for other group members, and then to identify the advantages and disadvantages of their notes. How group students (Group 7) reflected on their own ideas in the group discussion are listed as below. The reflective sentences are in bold.

c520	I think I should **strengthen the connections between *[My idea]* part and *[I need to understand]* part** for my own note.
c535	I have written three points in the *[My idea]* part. But I think it is difficult for other students to choose one of them to build on. In the part of *[I need to understand]*, I think **I should firstly deeper build on my own knowledge** about "How do bones and muscles work together?"
c535	**How do you think about the drawbacks of your note**, c541?
c541	I think **I should write more in the *[My idea]* part**, i.e. complement *[My idea]*.
c535	**Do you think which part of your note can be improved**, c504?
c504	I think **I should write more details**.

Both students c520 and c535 discovered that although they adopted two scaffolds, they did not build their questions created in *[I need to understand]* on what they have already known in *[My idea]*. Student c541 found that her question asked in *[I need to understand]* is not clear so that it needed further revision. Student c504 recognized that he should write more details to describe his ideas and problems (see Table 1.). In addition, student c535 can provide new metacognitive scaffolds to his group members such as "the drawbacks of your note", and "which part of your note can be improved".

Solving fact-oriented questions, integrating similar ideas, and structuring collective ideas

Another excerpt from Group 7 is shown as below. To create the group-level knowledge note, students tried to solve simple problems through different expertise, to combine homogeneous ideas from different students, and to combine each other's ideas and expertise to higher-level themes. The relative sentences are in bold.

c520	We can **put our ideas together**.
c535	Both of c520 and c504 talk about the speed of an object, so we can **put these two notes together**. Can we put c541 and mine together?
c520	We can select c541's note. Because **there is no connection between *[My idea]* and *[I need to understand]* in c535's note**.
c535	I have a new idea that **we can further enrich c541's note**……
c520	But I think the answer for c541's question is "No"! (explain the reasons……)
c535	So, we cannot judge whether we are moving without the reference. We should further combine the questions in c520 and c504. **We can combine them into one note**.

Students c520 and c535 played an absolute dominant role in this short conversation. After c520 provided the Knowledge Forum scaffold *[putting our ideas together]*, c535 found the similarity of c520 and c504's notes, as well as c535 and c541's notes. Then c520 proposed to exclude c535's note because there is no relationship between the scaffolds *[I need to understand]* and *[My idea]*. Therefore, c520 hoped to build on c541's note. However, c535 knew how to solve that problem and explained the answer to her group members. In the end, they decided to build on c520 and c504' s notes, and then created a new group artefact with strong connections between *[I need to understand]* and *[My idea]* (see Table 1.).

Initiating preliminary data collection for new ideas

In the face-to-face discussions, students often creatively found new ideas and identified learning gaps. Students of Group 2 tried to use real life materials to collect evidences to continuously revise the group's new ideas. See the excerpts below.

c539	Is the motion mode related to the motion speed?
c519	The motion speed and the motion mode are two different concepts. **For example, this round pen moves like this, while that thick pen moves like that.**
c538	**Will the pen move like this?**
c519	I will try to keep the same speed of my hand.
c538	But the forces exerted by your hand on the two pens are different.
c519	I will try to keep the same force, **just like this**… Is the motion mode of the two pens related to the speed?
c524	Because this pen cannot scroll.

c539 The motion modes of bike and motor are all curvilinear motion. However, they have different engines, so they share different speeds.

c519 Therefore, the mode the object moves, and the speed of the movement are irrelevant.

c539 I have another question, how does one object move?

c524 Exert a force on the object.

c519 For example, we need to exert a traction to move a car. **The object which cannot move itself, such as pencil box, cannot move without a pull or push.**

c524 Apply an upward force to the object or add weight to the car. Anyway, they are forces.

c524 **But the car cannot move when we put some counterweights on it.**

c519 Because the counterweights are just placed on the car…

To address the problem raised by c539, c519 exerted two forces on two pens to make them move. He found the two pens shared different speeds even though they had the same kind of motion mode. Therefore, he concluded that "there is no relationship between the motion mode and the motion speed". In this process, c538 argued that c519 could not exert the same force on the two pens simultaneously. Meanwhile c524 argued that the two pens themselves are different in terms of the shape. Then their discourse transitioned from the relationship between the motion mode and the speed to how the object moves. Their experiments of pushing/pulling/throwing the pencil box proved that "the force can make the object move". They also found that the downward force cannot move the object. Therefore, they combined their exploration of "relationship between the motion mode and the speed" with "relationship between the motion speed and the force" to construct the group artefact: "If we exert the same force to an object to make it move linearly or curvilinearly, which will be faster?" (see Table 1.).

Reflecting the process of group discussion

It is difficult for a few low-achievement groups to promote group knowledge during the first group discussion. However, students in those groups could reflect on their own discussion and identify strategies for successful discussion. This is an excerpt from Group 2. The strategies are in bold.

c513 This is the first time for us to conduct such discussion. We did not get along very well. **We are able to discuss constructively**.

c531 So did I. There may be a lot of different problems when we discussed because that is the first discussion. I think **we should select promising ideas to discuss**.

c542 I think that we almost shared the same ideas for our individual notes. Therefore, there is not much space to build on. Since everyone's idea is same, **we should build on each other rather than writing repetitive things**.

c507 I think that we are so hurry in the process of discussion. **There was not enough time to think about them**.

The group was dissatisfied with neither their group discussion process nor the group artefact. Therefore, they initiated another discussion about the discussion on the question: how to rise above their individual ideas to group knowledge. For example, they thought that they did not engage in constructive discussions because they just simply shared their individual notes. They also thought that they should have selected and discussed promising ideas to discuss and think about before discussion.

RQ2: To what extent did the group-level offline discussion facilitate collective knowledge?

Collective knowledge advancement in Class A and Class B

Our analysis of community knowledge focused on the intersection parts of all seven sub-topics. To this end, we used UpSetR to visualize the distribution of keywords in different topics (see Figure 2). The crossline links the subtopics whose certain key words are overlapped and the number of these overlapped key words are indicated over the corresponding bin. For instances, in Class A, there are two key words "5 Newton" and "overweight" overlapped in the subtopics T6 and T7, and one common key word "speed" appearing from subtopics T1 to T6. In Class B, there is one common key word "unit of force" in T6 and T7, and one common key word "speed" in T1, T2, T3, T5 and T6.

There are 24 and 17 crosslines in Class A and Class B respectively. In terms of the number of crossed subtopics by the descending order, "speed" in Class A crosses through six subtopics, while its number in Class B is just five; there are four crosslines crossing through four different subtopics in Class A rather than just one crossline in Class B; there are eight crosslines crossing through 3 different subtopics in Class A, while the number is six in Class B; there are eleven and nine crosslines crossing through two different subtopics in Class A and Class B respectively. In the aspect of the timeline, subtopics T1 to T4 focused on "motion", while T6 and T7 focused on "force". T5 might be overlapped most times because students talked about "the relationships between force and motion". It can be clearly seen that T5 are linked the most times in Class A.

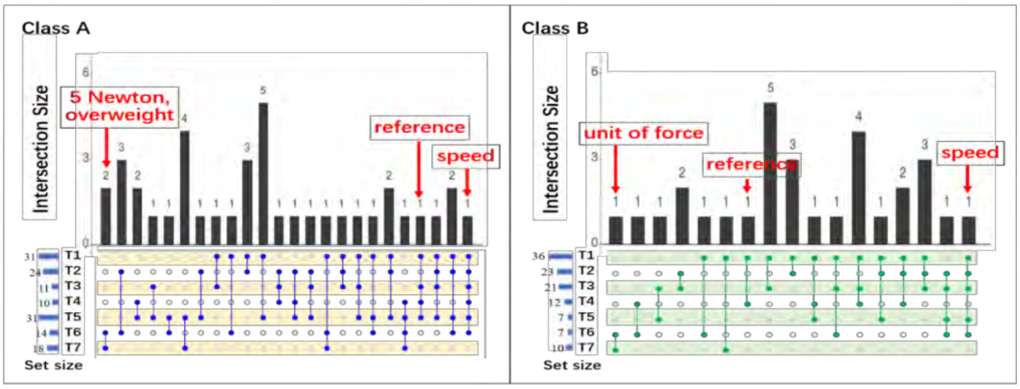

Figure 2. Keywords distribution in seven subtopics of Force and Motion

Group differences in collective knowledge advancement of Class A

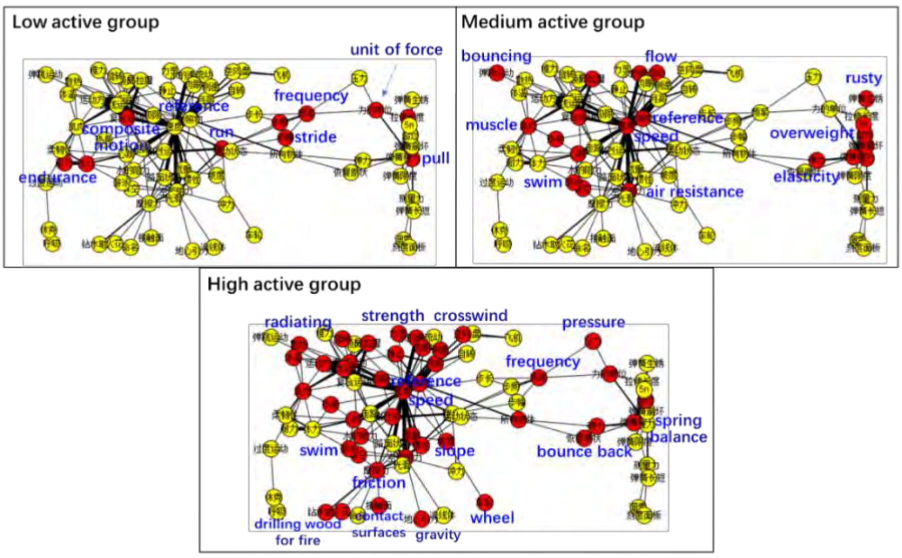

Figure 3. Social network of words in low/medium/high active groups

We compared group differences in terms of the collective knowledge advancement of Class A. First, we selected three groups as low/medium/high active group according to the number of adopted key words. Then we compared the groups' word networks through KBDex. Red balls in Figure 3 mean that those key words have already been discussed by the selected groups, while yellow ones represent key words discussed by other groups. The results show that: the high active group could integrate the central words with those marginalized ones, the medium active group conducted central words and marginalized ones separately, while the low active group could just adopt a few words located in different areas.

Conclusions and discussions

This study examined the offline group discussion in the large knowledge building community. This study engaged students in the face-to-face group discussions and create a group-level note before the whole community activities on Knowledge Forum. We also identified several characteristics of such group discussion: reflection on individual notes, rise above group notes and meta-discourse. Correspondingly, students in the offline discussion class showed higher socio-dynamics of collective knowledge advancement but unbalanced expertise in different groups. Deeper analysis of student interview and Knowledge Forum discourse underway to examine the process of how such offline group discussion affects online Knowledge Building Discourse. In addition, this study was conducted in the eastern culture with larger size classes than those in the western countries, the effectiveness of offline group discussion in other cultures with different class sizes needs further exploration.

Substantial future work needs to explore new tools to support the face-to-face discussion. For example, we should design strategies to help students discuss their online discourse in offline groups; and explore technologies for supporting synchronous transcription of oral discussion into text-version Knowledge Forum note. Moreover, diverse expertise showed in different groups inform that future instructional design should focus on the connections within groups in order to achieve the transformation from group knowledge to community knowledge. Finally, the emergence of unbalanced participation for online discussion from different groups inspired that future work should focus on instructional design to encourage low achievement groups to engage in both the offline and online discussions.

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An integrated inquiry about energy and environmental issues in a grade 5 classroom

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Abstract: This study explores interdisciplinary knowledge building in a Grade 5 classroom. In the four-month inquiry, students explored two core topics at the intersection of their science and social studies curricula: (a) conservation of energy and resources (b) the role of government and responsible citizenship. Students' inquiry was supported by Knowledge Forum (Scardamalia & Bereiter. 2006), a networked collaborative knowledge-building environment as well as Idea Thread Mapper, a timeline-based collective knowledge-mapping tool (Zhang et al., 2018). The data analysis examines the integrative inquiry design and process in light of the interdisciplinary understanding framework suggested by Boix Mansilla (2005), drawing on multiple data sources including audio/video recordings of classroom discussions and activities, field notes, students' assignments and online discourse, and the journey of thinking reflection written by students. This work contributes to elaborating designs and processes of interdisciplinary inquiry in a collaborative knowledge building classroom.

Introduction

Recent education reforms in science and other areas call for efforts to engage students in authentic and inquiry-based practices in line with how knowledge is constructed and practiced in the real world (e.g. National Research Council, 2012; NGSS Lead States, 2013). Beyond individual domain areas, students develop deep understandings of cross-cutting concepts, which have application across multiple domains (NGSS Lead States, 2013). As an important move, OECD proposed interdisciplinary and collaborative learning alongside mastery of discipline-based knowledge (2018). In Capacity Building Series, Ontario Ministry of Education similarly underlines that "Over half a century of researchers and teachers have explored curriculum integration as a way to meet the many demands of 21st century curriculum and to make classroom instruction more manageable and more engaging." (2010, p.1) Accordingly, such reform documents call for curriculum integration with the aim of developing interdisciplinary learning and understanding, connecting content and/or skills from different areas. A challenge arises pertaining to how interdisciplinary understanding can be developed through inquiry-based practices. The current study explores the possibility of developing interdisciplinary understanding through knowledge building in a Grade 5 classroom.

Knowledge Building (KB) pedagogy engages students in the production and continual improvement of ideas of value to their classroom community (Scardamalia & Bereiter, 2003). potentially KB offers an epistemologically grounded approach to interdisciplinary learning. As Boix Mansilla (2016) highlighted, an epistemologically grounded view of interdisciplinary learning is grounded on the construction of purpose-driven, disciplinary-grounded, integrative and inevitably provisional understandings. KB provides 12 fundamental principles, some of which are connected with interdisciplinary learning. For example, the principles of improvable ideas and rise-above encourage learners to work with ideas to improve the quality, coherence, and utility during the whole process instead of focusing on teaching disciplinary parts and holding the synthesis for the end. To be able to respond the needs in a constantly changing world, learners should be able to make connection between their (formal and/or informal) learning experiences to the real world. In addition to authenticity, learners should be intentional learners (Bereiter & Scardamalia, 1989) who have a sense of purpose in their learning and have learning as a goal rather than an incidental outcome.

Boix Mansilla (2005) recommended a frame for revealing student interdisciplinary understanding. We apply this framework in this study to analyze the grade-five interdisciplinary inquiry. This tool guides our attention to four dimensions of the work (see Figure 1): (1) establishing purpose; (2) weighing disciplinary insights; (3) building leveraging integrations, and (4) maintaining a critical stance/thoughtfulness.

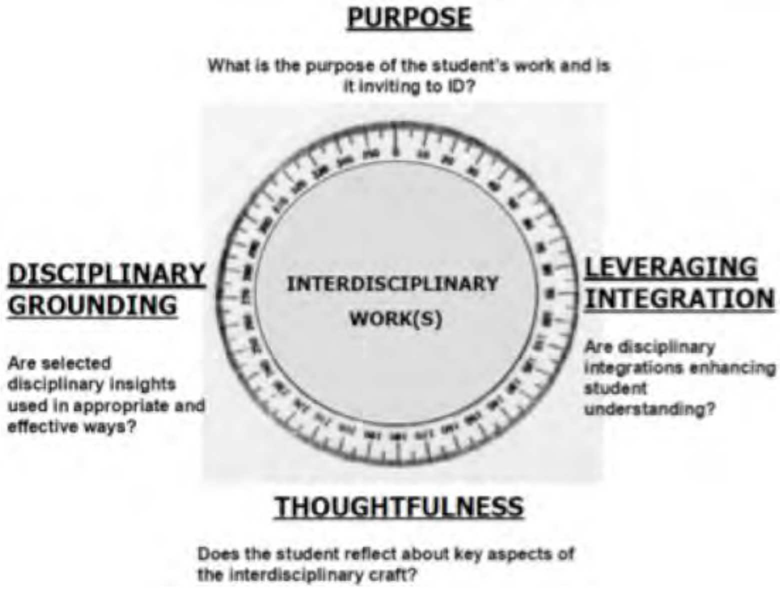

Figure 1. Four dimensions for revealing student interdisciplinary understanding by Boix Mansilla, Retreived from http://www.interdisciplinarystudiespz.org/pdf/VBM_Assess-ID-Understanding.pdf

(1) Establishing purpose: An interdisciplinary work starts with the clear definition of the purpose including description of the multidimensional phenomena and complex problems. This purpose should invite student to an interdisciplinary approach. Teachers are supposed to provide clarity about the purpose for the student and build a structure that calls them to make best use of the multiple disciplinary insights explored in the unit or course.

(2) Weighing disciplinary insights: The main idea of the interdisciplinary work is that students' inquiry is fed by different insights, findings, methods, techniques, languages, and modes of thinking in at least two disciplines of expertise to accomplish their goals. In this dimension, teachers identify and examine which disciplines inform students' work in general; in what ways the disciplinary perspectives taken by the students fit on the purpose of their work; and how students use the learning advantages of different fields to advance their understanding.

(3) Building leveraging integrations: For a deeper and richer understanding, students are supposed not only working around multiple disciplines but also integrating these different disciplines to accomplish the purpose of a piece of work. It becomes possible to develop new understanding when the multiple disciplines are combined. Teachers are supposed to identify the integration points of the multi disciplines; at which points it is possible to bring disciplinary perspectives together in a phrase, metaphor, interpretation, or explanation. Teachers should also evaluate whether students are able to produce more comprehensive descriptions, provide multi-causal explanations, or go for deeper explorations as a result of this integration.

(4) Maintaining a critical stance/Thoughtfulness: This dimension refers the ability of the students carefully taking choices, possibilities and challenges into account. This is a significant characteristic of interdisciplinary work process. Teachers evaluate students' reflections about the learning challenges and possibilities that were caused by taking different disciplinary perspectives. Teachers explore the key aspects of doing interdisciplinary work in students reflections on inquiry process and final works; what kind of possibilities provided by integrative work, any insight gained along the process, what type of challenges they faced in bringing multi disciplines, and so on.

This study aims to provide the design and analysis of KB inquiry for interdisciplinary understanding in a grade-5 classroom in the laboratory school of University of Toronto where KB pedagogy and Knowledge Forum (KF, Scardamalia & Bereiter, 2006) has been implemented for a number of years. The students are very familiar both with the pedagogical approach and with the technology. Even though the classroom teacher and intern-teacher were newly introduced to this innovation-driven pedagogy, they took courage to learn and run it with a high motivation. Therefore, teachers designed a scientific KB inquiry integrated with literacy and math. Our research question asks: How does KB support interdisciplinary understanding in this integrated inquiry?

Method

Classroom Context and Participants

This study was conducted in a fifth-grade science classroom with 23 students (12 boys and 11 girls) in Spring 2018. Even though the teacher (Ms. T) had 13 years of teaching experience, she was newly introduced to KB pedagogy and the supportive technology KF. Besides, the intern-teacher (Mr. M) had a significant role in designing and running the classroom collaborative inquiry.

Following KB processes, the students investigated conservation of energy and resources using KF over a whole school year, with two-hours science sessions in each week. In a broader scope, the focus of students explorations was around "How do our choices impact local, national, and global communities?" and "How can we influence change to enhance our well-being along with others?" Teachers made use of the connections between two significant topics from Ontario Grade-5 Curriculum in their teaching design: (1) conservation of energy and resources under the understanding earth and space systems unit (science) and (2) the role of government and responsible citizenship under the people and environments (social studies). The four-month inquiry process began in late January in 2018.

Data Sources and Analysis

To investigate the inquiry on energy and environmental issues, we analyzed multiple data sources; audio/video recordings of classroom discussions and activities, observation notes, students' assignments and online discourse, and journeys of thinking.

Journey of thinking is a kind of synthesis of a line of inquiry –written by the students themselves- that aims to describe their progress over time. It is aided by a set of scaffold supports such as our problem to define what their goals/problems were, we used to think/ we now understand to explain what big ideas they have learned so far, and deeper research to prescribe what deeper actions would be required as the further steps (Zhang et al, 2017; 2018).

We grounded data analysis on the four-core process for dynamic interaction suggested by Boix Mansilla (2005): (1) establishing purpose; (2) weighing disciplinary insights; (3) building leveraging integrations, and (4) maintaining a critical stance (thoughtfulness). In align with the four-dimension framework, we first described the purpose of students' inquiry and how it was related to interdisciplinary subjects. Then we identified the key concepts and skills from different disciplines that were used in KB inquiry.

Results

The teachers believed that curriculum subjects should not be taught in isolation but as a series of connected topics that build on each other to enhance our understanding of the world and enable us to change it for the better. Teacher's goal of designing this integrated inquiry at the intersection of science and social science, also connected with English Language and Art and Math is to empower students to examine the social and environmental impacts associated with the production, use, and disposal of such materials and to develop an advance explanation of the human factors and scientific facts on energy and environmental issues and their relation with global warming and climate change.

Teacher kept their effort on supporting students to iteratively construct and progressively clarify the purpose by aligning their prior understanding of the subject matter, wondering areas, and inquiry interests. While identifying interdisciplinary goals, teachers were highly considerate to communicate and collaborate with the students as the main investigators of this integrated inquiry.

The general purpose of this integrated inquiry is to create an understanding for the students around two major problems: “How do our choices impact local, national, and global communities?” and “How can we influence change to enhance our well-being along with others?” To establish this purpose, Ms. T and Mr. M decided to act on through the creation of long-term units that relate curriculum content and concepts to meaningful applications that students are passionate about and familiar with. Working around this general goal, students were encouraged to explore the concept of matter to understand the properties of matter and changes in matter. On the other hand, as the best environmental stewards and grade-five students worked on a persuasive writing to provide consultation to the government for investing a large sum of money into creating technologies that harness the energy from one renewable energy source. Therefore, students were encouraged to understand the government's’ environmental policies and the impact of their decisions on the on environment. They continued to discuss this question in the debate session as in groups.

Throughout the inquiry process, teachers encouraged students to revise their ideas and questions and take different disciplinary perspectives relevant to address the given problem (e.g. science, civic and cultural issues, language, math and so on). In order to do this, students always worked back and forth on their initial questions and explored the different aspects of their inquiry. For instance, teachers created a science exploration lab as a response to the questions students were posing about energy and environmental stewardship. —Students recorded their initial questions on post-it notes (and later on KF) about the human impact on the earth based two different sets of images. The first set of images were related to environmental stewardship to get them thinking about our impact on the earth and the second set of images were related to forms of energy to get them thinking about what this concept means and its relationship to environmental stewardship.—

These questions were collected and organized into four categories based on their framing (see Figure 2) and during science inquiry process, students were encouraged to revisit these questions and explore the answers and respond on the research-and-response handouts. To ensure that this is an ongoing exploration, teachers provoked students not only sharing the new information they found about the questions on the exploration wall, but also to share their responses with the whole class during KB circles held weekly. Students continuously added to the exploration lab, and this process of question generation became natural for students as the more in-depth topics are explored the more complicated.

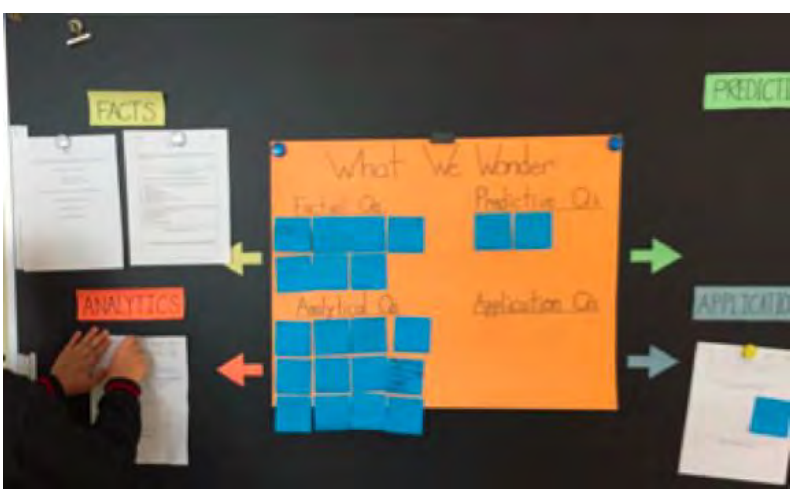

Figure 2. Students' questions, collected and organized into four categories based on their framing

To advance a plausible and satisfactory explanation energy and environmental issues students are supposed weigh the explanatory contributions of various disciplinary insights. Understanding how greenhouse gasses affect the hole on the ozone layer is the area of physics. Yet the actions might be taken against to pollution by humans are typically studied by environmental studies. The global and local energy policies are considered as the subject of political sciences and law studies. To develop a terminology-based explanation of global warming, climate change, and pollution, students investigated the geographical structure of the earth. Teachers created a contextual word wall (Figure 3), which took the form of a large diagram of the earth that reflects two futures. On the right side, it is illustrated a polluted and fading earth; while on the left side, an earth that is beaming with life. Throughout the science unit, students attached their definitions to this diagram to create a beautiful illustration of our earth affected/unaffected by climate change and a set of facts and term definitions that explains these depictions.

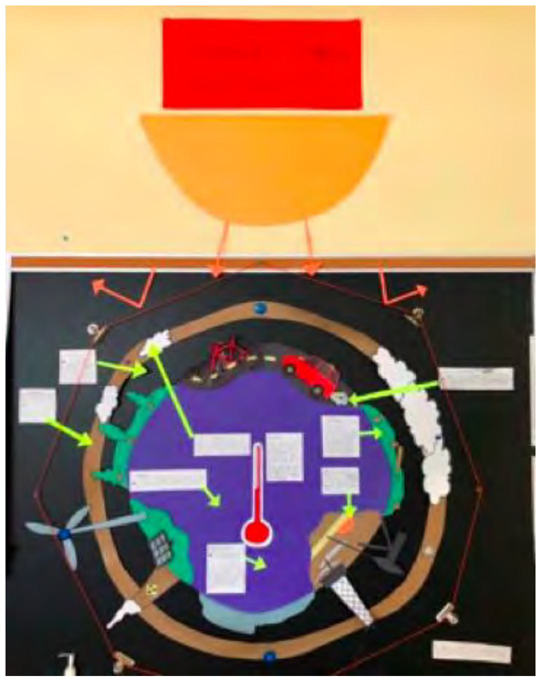

Figure 3. The contextual word wall that took the form of a large diagram of the earth that reflects two futures.

During the integrated inquiry process, students were charged with assignments and projects at different scales. To exemplify small-scale assignments; persuasive writing about famous electrical scientists, presentation and a debate session about different energy sources, math journals, and so on. Additionally, students were assigned a large-scale project to design a mobile application to educate individuals on their energy consumption and how to better conserve this along with other natural resources. These applications took a number of forms from step trackers to games to convertors. Throughout these activities and events clarity of the purpose to develop awareness about the energy consumption and environment helped students to decide what the focus and scope of their investigation, what intrinsic in their project, what the meaning in their efforts, and what the parameters of success.

In addition, students had a continuous discourse on KF. For example, one of the questions students worked around on KF was "What will happen if we ignore the science on climate change? What would our earth just look like in 20, 50, and 100 years?" led students to think about the future of the earth and seek the solutions to avoid dark future scenarios in their KB journey. Similarly, these type of questions empowered them to define their applications' goals "What is the purpose of their mobile application?" and "How do people benefit from this app in favor of environment?

In the debate session, students researched not only about the pros- and cons- of the different energy sources, they also explored the governmental policies and the efforts of affective social groups. Persuasive writing and debate session gave the opportunity to students for learning and experiencing the main elements of an effective persuasion; (1) Ethos; intelligence, trustworthiness, and morals; (2) Pathos; emotions, prejudices, and motivations; (3) Logos; evidence, data, universal truths.

Conclusion

This research provide a good example of an interdisciplinary learning that is a demanding model for students' learning how to think and act around the contradictory or incompatible ideas by taking different aspect into account in short- and long-term perspectives. We highly recommend working with KB pedagogy and technology for teaching students authentic issues and dilemmas around complex situations. We framed our KB work in Mansilla's interdisciplinary learning approach. The results of the preliminary analysis showed that grade-five students evaluated the problem by converging scientific facts, social issues, biological/ecological consequences, geographical knowledge and so on. As a next step, we are planning to explore the connection between students' online contributions during the term and journey of thinking synthesis. Therefore we aim to reveal their learning process over time and the links they made among the different disciplines. We also aim to analyze interview data to understand students' reflection process.

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Transformation of Teachers through Knowledge Building: Utilizing a "Growth Mindset" in a Secondary School

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Abstract: The purpose of this research is to examine challenges and key components of transforming teaching practices into Knowledge Building practices and fostering a knowledge-creating culture in classrooms. Accounts are based on semi-structured interviews with four social science teachers and a school principal. Grounded theory analysis is used to identify themes. This work is part of a larger research project in Ontario to support uptake of Knowledge Building; components of that broader initiative are also presented.

Introduction

This paper provides an account of ways in which high school teachers' practices changed in the course of initiating Knowledge Building in their classrooms.

Alignment of schools to 21st century education goals and challenges not only represents a dramatic shift in traditional approaches to professional development, it also requires a shift in mind-set of teachers and the very culture associated within teaching practices (Fullan, 2007). Chai & Tan (2009) argue that it is imperative that teacher-researcher teams co-construct new knowledge and teaching practices to develop 21st century competencies. The shift from traditional forms of teacher professional development to innovative teaching practices requires institution-based change in a broad sense; indeed Hargreaves (1999) argues that in knowledge-creating schools the school system has already embraced knowledge creation as a goal. Knowledge Building (Scardamalia & Bereiter, 2006) emphasizes work with ideas "to the most advanced levels of theorizing, invention, and design, and across the spectrum of knowledge creating organizations, within and beyond school"; it represents a way of transforming education at student and organizational levels.

In order to introduce and diffuse Knowledge Building throughout the province, the Ontario Ministry of Education Literacy and Numeracy Secretariat (LNS), three principals' councils (the Ontario Principals' Council, the Catholic Principals' Council, and l'Association des directions et directions adjointes des écoles franco-ontariennes), and Curriculum Services Canada have collaborated since 2013. Knowledge Building has been advanced within the Leading Student Achievement Networks for Learning project and the Tri-Board Knowledge Building project involving University of Toronto researchers (Leithwood & Miller, 2012; Resendes et al., 2016). The Leading Student Achievement initiative places 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).
The partnership enabling spread of Knowledge Building has been described in various Ministry and principals' council presentations as a school-university-government partnership--a multi-level approach to provide support to school leaders at provincial, district, and school levels. At the provincial level, representatives from the three Ontario principals' associations mentioned above and partner institutions form the Leading Student Achievement Steering Team. This team provides guidance and resources to the project and organizes provincial symposia. At the district level, participants are organized into Principal Learning Teams and at the school level, principals and vice-principals create Professional Learning Communities. As of 2015, in its tenth year, the Leading Student Achievement Project includes 57 districts, 3210 principals and vice principals, and 123 system leaders.

Methods

This current study aims to explore a successful case of creating a Knowledge Building culture in a secondary school. The research focuses on one site within the larger project; the full extent of Knowledge Building uptake within the broader project is not known and toward that end a separate initiative is underway to bring participants together in a Knowledge Building Innovation Network. At this early stage of the research the goal is to focus on one school to understand challenges and possibilities for realizing school change. More specifically, the research focuses on transformation from more traditional forms of teaching to innovative classroom practices in social science classrooms in one school.

Semi-structured interviews were conducted with the school principal and four social science teachers. Interview data were analyzed using a grounded theory approach (Strauss & Corbin, 1998).

Participants

At this secondary school Mr. B is the departmental leader of the Canadian World Studies. As of the 2016 school year, he had taught a combination of History and Math classes for seven years. Mr. C also has seven years teaching experience with various social science course, including Geography, History, and Law; Mrs. D similarly has seven years teaching experience including courses in History, Geography, and Physical Education. The fourth teacher, Mr. E, is the most experienced teacher with 17th years; he has taught Science, Phys-Ed and Health courses and served in an administrative position in 2016 .

Results

The following themes and subthemes, identified through grounded theory analysis, reflect participants' views of essential factors for establishing a Knowledge Building culture in their school:

Alignment of school improvement goals with the innovative pedagogy

The school principal noted that the school goal focuses on three themes: *instructional practices, assessment*, and *a growth mindset*. The school improvement goal regarding instructional practices focuses on 21st century learning skills such as critical thinking, problem solving, deep learning. As elaborated in Scardamalia, Bransford, Kozma, & Quellmalz (2012) Knowledge Building principles map on to 21st century competencies and to the three school themes. For example, the Knowledge Building principle "concurrent, embedded, and transformative assessment" corresponds to the school's assessment goal. Mrs. A underlines the importance of being clear about their expectations and students' goals and how to achieve them. Teachers help students establish success criteria, provide descriptive feedback, and close the gap between academic and applied students. The Knowledge Building principle *Community Knowledge, Collective Responsibility* refers to a collective growth mindset: each student in the community takes responsibility for generating and improving ideas for the whole community. In line with this, the Knowledge Building principle *Epistemic Agency* points to the need to transfer to students high-level agency for setting goals, planning, monitoring progress, evaluating idea improvement.

Alignment of teacher's goals for teaching and learning with the innovative pedagogy

Teachers mainly referred to the importance of turning agency over the students. Some teachers referred to this as student directed learning, with reference to engaging students in deciding what is valuable for them to learn. Some teachers explained that they aim to break student dependence on the teacher as the authority figure who sets and refines all goals and instead create a more democratized learning environment that engages everyone. Teachers defined their role as learner and learning partner. Mr. C specifically stated that he aims to encourage students to develop critical thinking and problem solving abilities. In line with Knowledge Building, he wants students to take the perspective of real social scientists' and historians', even if they do not choose that jobs in the future.

Creating a supportive school culture

All teachers and the school principal, Mrs. A, spoke about a learning culture in their school. As Mrs. A noted, at both the school and school board time is provided for professional learning communities. As of 2015, in its tenth year, the Leading Student. Mrs. A encourages teachers to choose the focus for their professional learning communities that fits under the umbrella for the school improvement plan surrounding 21st century learning skills. She organizes professional development days, inviting experts, arranging staff meetings and special learning days for instance Fruit Fridays or Soup Tuesdays where they come together to have soup for lunch. These provide opportunities for teachers from different departments and different grades to engage in sustained discourse and to work together to advance their practices.

Additionally, the school structure and use of space encourage collaboration. There are no private department offices; instead teachers meet at three spots at recess and when there is spare time, with focus on school discourse. They refer to the *department or program leader* rather than *head of the department*.

Mrs. A emphasised that there is a leadership component to their role in addition to management dimension and each of the program leaders leads the professional learning communities as well.

Teachers are enthusiastic regarding their work together. They mentioned that they have ongoing conversations about classroom practices, always sharing with each other what they are doing in their class; they never hesitate to ask questions to learn from each other, or ask for suggestions, comments, and support.

Another design component of the school that supports ongoing collegial collaboration is the school's open door policy. As Mr. B explains anyone can walk in and out of any classroom to see what someone is doing and possible catch a glimpse of a "cool unique idea." They also have a time-schedule called "pineapple" where the teachers can mark their class time to invite others when they especially want them to see their practice.

Sustained support from the system

In order to investigate ways in which teachers received supports from the system, several interview questions focused on how work with other teachers is supported within the school and across the school board and how teachers are supported in implementing Knowledge Building in their classrooms. Teachers reported that they were encouraged to create professional learning communities, attend regular staff meetings, and engage in professional development sessions and experiences organized by their school boards and by the Leading Student Achievement project. Leading Student Achievement encouraged principals to discuss and develop principal learning teams projects to improve student and teacher success. As a result of a principal learning team Mrs. A was originally introduced to Knowledge Building. Teachers disseminated it further through their school board; they organized workshops and seminars, and collaboration sessions across subjects and grades. Leading Student Achievement further organized virtual learning sessions, regional symposia, talks by experts, provided Knowledge Building resources and helped produce classroom examples and a Knowledge Building Gallery (http://thelearningexchange.ca/pdf/knowledge-building-gallery/).

Challenges

Time was reported as the biggest challenge: there is never enough time for formal professional development activities. Mr. B said that "there's really a small amount of time that you can direct to advancing who you are as a teacher in your actual practice." Mrs. D mentioned, they need more time and financial support for formal professional development. On the other hand, she thought their department's effort is beneficial because they do so much on their own and that's how they work around the obstacles that they face in terms of time-- they use their personal time for discussions and to deepen ideas.

Another major challenge reported was uncertainty regarding a key facet of Knowledge Building. Even though the teachers in this case study identify themselves as risk-takers, they express uncertainties, especially in regard to turning control over to students. This became easier, they report, as they encouraged each other, shared experiences, collaborated on lesson plans, observed each other's classrooms, and co-evaluated their classroom practices.

While not a barrier within the school in question, one participant noted lack of support can be a major barrier. Mr. E said that he felt isolated at his previous school when he started to implement Knowledge Building because there was no other teacher engaged with Knowledge Building, he felt he was doing something "unorthodox." When he started to teach at his current school he found a group of teachers working effectively with Knowledge Building and came to better appreciate his own-work and be motivated to improve it.

Discussion and Significance of the study

The current case study provides a look at one school's effort to transform its practices to be more in keeping with Knowledge Building theory and pedagogy. In order to achieve this goal, teachers in a social sciences department, with support from their principal and a provincial project, put in place conditions to advance their practices. This study provides a look at conditions that enabled a single school to begin its professional transformation.

In a broader sense, this research addressed a significant gap in Knowledge Building research. Most of the available research has focused on what students do in Knowledge Building Communities rather than on teachers' practices. While it is recognized that fostering Knowledge Building is challenging for teachers (Zhang et al., 2011), little empirical work exists that explores how teachers create Knowledge Building Communities in their classroom. This thesis research helps to rectify this imbalance in Knowledge Building research and informs the development of Knowledge Building: Professional Development. A close look at a provincial initiative to advance Knowledge Building provides a detailed account of how Knowledge Building evolves through practice and professional development and the extent and means of spread of Knowledge Building practices. Of particular interest are ways in which principals are engaged themselves as change agents and how teachers take on and turn over high-level socio-cognitive responsibility to students.

Because this study was conducted within an ongoing Ministry of Education sponsored LSA initiative it provides feedback to inform a Knowledge Building Theory of Action for educators and policy decision-makers for current and future Knowledge Building and professional development, both within and beyond Ontario.

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Designs for Visualizing Emergent Trends in Ideas during Community Knowledge Advancement

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Abstract: During Knowledge Building, students engage in collective responsibility for knowledge advancement. A major challenge for students and teachers alike is assessing collective progress. This paper aims to explore next-generation designs for visualizing emergent idea dynamics during community knowledge advancement. First, word clouds, idea threads, and idea networks are reviewed to highlight the strengths and limitations of each analytic tool in Knowledge Forum. "Idea trends" is then proposed to complement these assessment methods through temporal visualizations of knowledge growth. An example is provided to illustrate how idea trends can offer new opportunities for symmetric knowledge advancement and pervasive Knowledge Building. Finally, pedagogical implications of these technological designs for sustaining idea improvement in the classroom are discussed.

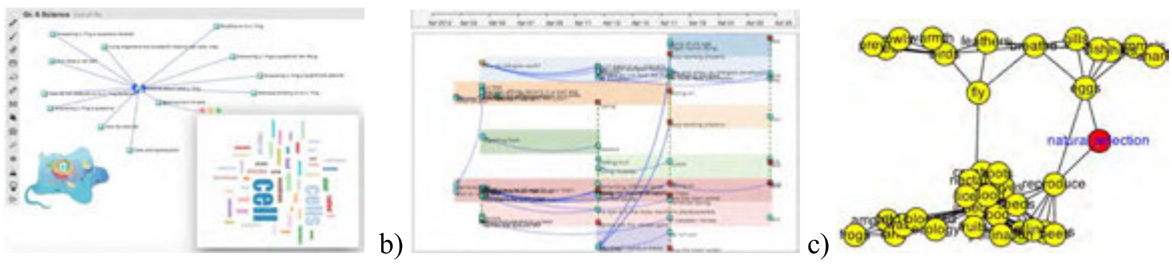
Introduction

Knowledge Building (Scardamalia & Bereiter, 2014) is an innovative pedagogical approach that aims to enculturate students of all ages into knowledge practices that promote and sustain creative work with ideas. The central goal of Knowledge Building is to produce knowledge of value to a community (Scardamalia & Bereiter, 2003), with all students assuming *collective responsibility* for knowledge advancement.

Knowledge Building is facilitated by a set of principles (Scardamalia, 2002) to bring student ideas to the center of classroom discussions. Key characteristics of these idea-centered discussions (or *KB discourse*) includes generating *real, authentic ideas*, making coherence among *idea diversity*, and finding new ways to test *improvable ideas*. While generating ideas come naturally to most students, improving ideas is often challenging. Ideas can be evolved through two processes: idea elaboration and idea diversification (Hong & Sullivan, 2009). While idea elaboration focuses on increasing the depth of ideas, idea diversification focuses on increasing the breadth of ideas (i.e., understanding how ideas interact with one another). Both are necessary for idea improvement. In order to build a culture of continual improvement in classrooms, discourse about discourse (or "metadiscourse") is also necessary (Resendes, Scardamalia, Bereiter, Chen, & Halewood, 2015; Zhang et al., 2015). Metadiscourse helps students *rise above* the current state of their community knowledge and reflect on their knowledge advances in order to re-assess the directions they are heading (e.g., idea elaboration, idea diversification) and plan strategically for future collaborative action.

Knowledge Forum

Knowledge Forum (Scardamalia, 2004) is an online collaborative environment designed specifically to support *pervasive Knowledge Building* in- and out- of the classroom. Using Knowledge Forum, students design conceptual spaces, called views, to visualize ideas big and small that belong to their community. In a given view, students contribute their ideas as notes, sketches, images, videos, and other multimedia, which then become built-on, cited, annotated, linked, and even synthesized into rise-above notes. Knowledge Forum also comes with a suite of analytic tools to assess socio-cognitive and socio-emotional dynamics that unfold during Knowledge Building. Furthermore, "multifaceted visualizations of ideas in the community knowledge" (Scardamalia, 2017, p. 402) are available at the click of a button to support student engagement in metadiscourse. In the following subsections, three analytic tools with the shared aim of visualizing community knowledge advancement and promoting metadiscourse are reviewed.



a) b) c)

Figure 1. a) Word cloud, b) idea thread, and c) idea network visualizations of Knowledge Forum discourse.

Word Clouds

The word cloud tool (Resendes et al., 2015) visualizes the most frequently used keywords in students' discourse; the more a keyword is used, the larger it appears in the word cloud. In line with the KB principles of *real ideas* and *idea diversity*, the word cloud tool can be applied as a quick heuristic to get an overview of the "big ideas" in the community knowledge.

In Figure 1a), the word cloud visualization is applied to student discourse about the "cell life cycle". Keywords picked up by this tool include: "cell division", "mitosis", "cytoplasm", ""nucleus", "chromosomes", "membrane", "organism", "reproduce", "food", and "water". It can be seen that "cell" is the most commonly used keyword, however, the ways in which the keywords are applied and connected to one another are not clear. Because the word clouds are computer-generated, students need to make those meaningful connections through metadiscourse.

When used as a formative feedback tool, the word cloud visualization can help students discuss and reflect on their own discourse, as well as the discourse of experts. In fact, comparative word clouds highlight points of convergence and divergence between the two forms of discourse. Recent studies show that metadiscourse with the support of word clouds enhance students' vocabulary and conceptual development (Resendes & Dobbie, 2017; Resendes et al., 2015). By visualizing the alignment of their discourse with those of experts, students can continue growing their community knowledge while making *symmetric knowledge advancements* with other Knowledge Building communities.

Idea Threads

The Idea Thread Mapper (ITM; Chen, Zhang, & Lee, 2013) categorizes student notes into specific inquiry topics and visualizes the build-on connections across these "idea threads" over time; the more sustained the discourse, the longer the idea thread. In line with the KB principle of *symmetric knowledge advancement*, ITM supports simultaneous progress within and across multiple inquiry topics in the community knowledge.

In Figure 1b), the idea thread visualization is applied to student discourse about the "human body". Idea threads shown in this tool include: "death" (dark blue), "allergies" (light blue), "memories" (dark orange), "heart" (light orange), "digestion" (green), "brain" (dark pink), "nerves" (light pink), and "sleep" (purple). At the top, there is a timeline (grey bar) that indicates when specific notes and threads were created. It can be seen that the "brain" thread was discussed for the longest period of time with a total of 11 notes connected. The "brain" thread is linked to the "memory" thread, while the "sleep" thread is linked to the "heart" and "death" threads; however, there is no link between the "brain" thread and the "sleep" thread.

ITM requires students to generate their own idea threads in light of shared community goals. When used to support metadiscourse, ITM can help students monitor the progress of each idea thread and review their community knowledge to identify gaps and future areas of research. Recent studies show that metadiscourse with the support of ITM helps students generate deep questions and engage in progressive problem solving, which lead to deeper, more coherent understandings (Chen, Zhang, & Lee, 2013; Zhang et al., 2015).

Idea Networks

The Knowledge Building Discourse Explorer (KBDeX; Oshima, Oshima, & Matsuzawa, 2012) visualizes keywords in a network: Keywords are represented as nodes and connections between keywords are represented as ties. Ties are created via co-occurences of keywords in student notes; the greater the co-occurrence of keywords, the thicker the tie in the "idea network". In line with the KB principles of *idea diversity* and *improvable ideas*, KBDeX can play the evolution of the idea network to highlight pivotal points in the discourse that led to idea improvement, such as when a novel connection between two ideas occurred and when an important idea entered the community knowledge.

In Figure 1c), the idea network visualization is applied to student discourse about "evolution". Keywords represented by this tool include: "mammals", "reptiles", "amphibians", "warm-blooded", "cold-blooded", "prey", "predator", and "natural selection". It can be seen that semantically similar words are closer together in the network – "fly", "birds", and "owl" in the top-left; "fish", "gills", and "shark" in the top-right; and "bees", "fruit", and "pollination" in the bottom – with "natural selection" being a central idea that ties these various themes together.

KBDeX requires students to generate their own word list before conducting socio-semantic network analysis. When used to support metadiscourse, KBDeX can help students reflect on group dynamics that support community knowledge advancement. Recent studies show that KBDeX aids students in identifying important ideas both at the core and periphery of their community knowledge (Matsuzawa, Oshima, Oshima, & Sakai, 2012). Having an understanding of who contributed important ideas to the community knowledge also helps students develop a deeper appreciation for collaboration (Matsuzawa, Tohyama, & Sakai, 2014).

In summary, the word cloud shows frequently used keywords, the idea thread shows connections across inquiry topics, and the idea network shows connections between keywords. Each tool brings pedagogical benefits; however, they are less suitable for providing students with a simple, automated visualization of emergent idea dynamics during knowledge advancement, such as the rise of "big ideas" that pervade multiple knowledge domains. In the following section, the "idea trends" visualization is introduced, along with recommendations on how it can support metadiscourse.

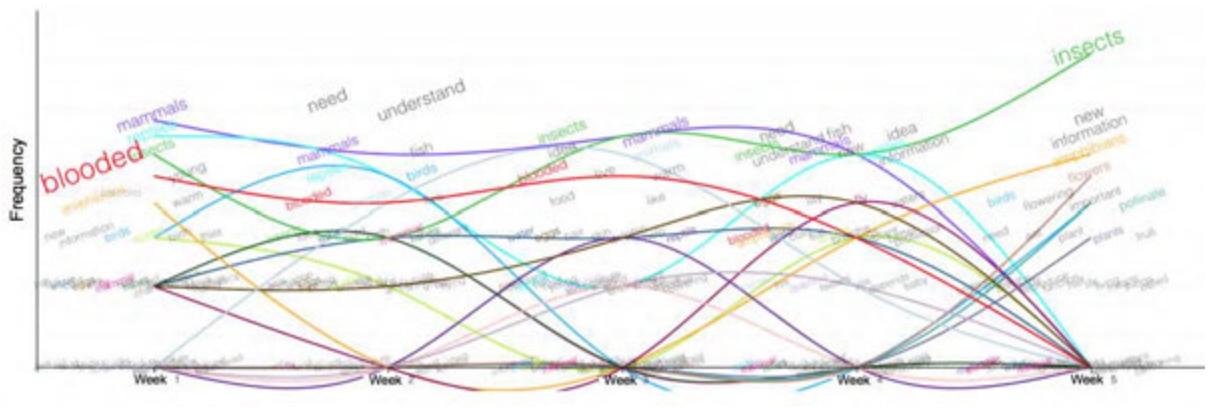


Figure 2. Idea trends visualization produced by Voyant Tools (Sinclair & Rockwell, 2016).

Idea Trends

The Voyant Tools (Sinclair & Rockwell, 2016) visualizes the trend of keyword frequencies over time, where the y-axis represents the frequency and the x-axis represents time. Each keyword is represented by a line, and the user can mouse over each line to explore the idea trend; when a keyword is selected, the line will change from grey to a bright colour. In line with the KB principles of *real ideas*, *idea diversity, improvable ideas*, and *symmetric knowledge advancement,* Voyant Tools can provide users with a quick overview of: frequently discussed ideas (like the word cloud), simultaneous progress across multiple topics (like the idea thread), and co-occurrence of ideas in the community knowledge (like the idea network).

In Figure 2, the idea trends visualization is applied to the same student discourse about "evolution". Similar to the idea network example, keywords represented by this tool include: "mammals" (purple), "reptiles" (cyan), "amphibians" (yellow), "blooded" (red), "birds" (blue), "fish" (grey), "eggs" (brown), "insects" (green), "flowers" (tan), "plants" (taupe), and "pollinate" (teal). It can be seen that the most commonly used words in Week 1 were "mammals", "reptiles", "amphibians", and "blooded" (in reference to warm-blooded and cold-blooded animals), whereas the most commonly used words in Week 5 were "insects", "flowers", "plants", and "pollinate". This indicates that over the span of five weeks, students had shifted their explorations about mammals and reptiles to insects and pollination. At the same time, it can be seen that some ideas had been relatively consistent in their use across the five weeks. For example, "water" maintained a medium frequency across Weeks 1 to 4, but dipped in Week 5. This trend is likely due to the fact that "water" is a central concept for understanding living things and their habitats, and it would be not be surprising if "water" re-emerges in later weeks as students continue discussing "plants" and "flowers". It is also interesting to note that while "bird" was relatively frequent across Weeks 1 to 2, it dipped in Weeks 3 to 4 (just as "mammals" was peaking) then re-emerged in Week 5 when the discussion had evolved toward "pollination".

Although these idea trends are computer-generated, they seem to provide meaningful information about temporal patterns within the community knowledge, and thus offer new opportunities for students and teachers to engage in metadiscourse. Students can identify common and unique ideas; explore positive and negative correlations between ideas; and extract important ideas that connect across various curricular areas. Some questions to guide such reflective group discussions include (but are not limited to):

- Which are the most/least common ideas in our community knowledge? Why is that so?
- Which ideas do/do not grow in parallel? Why is that so?
- Which ideas are not growing? Which ideas were abandoned? Why is that so?
- Which ideas are consistently present in our community knowledge? Why is that so?

- Which ideas are we missing in our community knowledge? Why is that so?

Lastly, idea trends have the potential to cultivate additional KB principles in the classroom, such as *pervasive Knowledge Building*. The idea trends tool can help students visualize "big ideas" as cross-curricular concepts. For example, the idea trends tool picked up "water" as a consistent "big idea" for students across four of the five weeks during their study of the evolution of life systems. This may not come as a surprise for teachers, who realize that "water" is a core concept in the curriculum, fundamental to understanding key scientific theories in biology, chemistry, physics, and earth sciences. Thus, engaging students in metadiscourse around this idea trend can facilitate the development of rise-above ideas and increased conceptual coherence, and ultimately, sustain their efforts at community knowledge advancement. Additionally, teachers can explore idea trends in real-time while students are engaged in Knowledge Building on Knowledge Forum to assess which "big ideas" in the curriculum they will likely discuss next, and use the visualization to help inform next steps in their pedagogical design.

Design Implications

The paper explores the design of a new analytic tool in Knowledge Forum, called "idea trends", with the aim of visualizing emergent temporal dynamics during community knowledge advancement. As researchers continue to improve technological supports for Knowledge Building, one central goal is to provide students and teachers with more holistic forms of feedback to support productive action, with each member better positioned to advance shared goals, adjust work as it proceeds, and explore new metadiscoursive practices that enhance progressive discourse and sustain collective progress.

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Knowledge Building Summer Institute,
'Knowledge Building: A Place for Everyone in a Knowledge Society'
Toronto, Canada, August 2018

Seeking Purpose Beyond Learning as Knowledge Building

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Demonstrative discussion

Abstract
The purpose of this session is to examine specific 'learning artefacts' and 'evidence of processes' created by children in a nursery and primary school education context that exemplify the collaborative building of knowledge. Their relevance and means of gestation lie in that 'space beyond' which I identify as the space beyond formalised learning, wherein lies Knowledge Building yet does not necessarily comprise it.

Introduction
The purpose of this session is to examine specific 'learning artefacts' and 'evidence of processes' created by children in a nursery and primary school education context that exemplify the collaborative building of knowledge. This is not to demonstrate that they have 'learned' something whether as content, skill or awareness, or have demonstrated creativity, or enabled some whizzbang, wonderful or indeed 'excellent' outcome. Their relevance and means of gestation lie in that 'space beyond' which I identify as the space beyond formalised learning. It is the space wherein lies Knowledge Building yet does not necessarily comprise it.

The examples arose in operational zones where I as teacher didn't control the learning or at least, not overly, in that I did provide parameters and wherewithal and set a context but did not seek to constrain, or more particularly, to specify. However that does not mean that there were not sophisticated or extensive frameworks, guidelines or curriculum components as a backdrop at school, education authority and system level. Indeed it was an awareness and appropriate utilisation of these, in the context of enabling learning and developmental opportunities, that these examples arose. The learning went beyond what I had planned or foreseen, to form in collaborative endeavour, entering the realm of Knowledge Building, as I see it, for there are many ways of seeing it, notwithstanding its formal definition and components (Scardamalia 2002) as underlie this Summer Institute.

Analytic perspective
The formal curriculum frameworks and components were very much there, but I viewed them as an overlay. Of themselves they do not switch on learning and enable personal development except in coercive form by making tests and grades the purpose of learning (Bower 2013). Whilst an array of content, skills and personal development was present and necessary, and was here sophisticated, I was interested in how children came to become aware of their own needs and potentialities which were expressed through endeavours as realisation of purpose. I came to see purpose as a primary enabler of motivation, and thereby means of acquisition of developmental potentials – individually and collectively – and so to the building of knowledge. In a small rural school context with multi-age classes and also having a large range of additional support needs I came to view my job as to provide a guiding theme, yet seeking to enable diversity, in such a way that there were cohesive tasks but a wide range of learning components and broader developmental opportunities. This approach emerged in a sense as educator Knowledge Building in which I and colleagues could best meet the diverse needs of pupils/students, in the sense of setting out the conditions to 'best' enable these, best only meaning the best as I could do as I could perceive relating to the needs and potentialities as I saw them. These were identified at the individual level, yet pupils/students with very different developmental stages and needs had to function purposively together. This disposed towards collaboration.

This is what attracted me to Knowledge Building and to other modes of thinking and practice within the same stable, in particular systems thinking, especially as developed by Seddon (2008). I and colleagues sought to to reach out to very diverse needs and potentialities of the pupils/students, also focussing on these as an unknown to be revealed (Bower 2013). In so doing we moved away from a focus on delivery, target and product modes of learning as 'learnification' (Biesta 2009) and performativity (Ball 2003) to the meeting of needs, spawning potentialities, and enabling capacities of personal development. That shift of locus is hard to pin down. It is teacher as collaborator, rather than as disseminator or adjudicator. Formal assessment could be viewed more as recording than grading. Evaluation moves from performance management to professional capital (Fullan and Hargreaves 2012), reversing the global trend of the last fifteen years, though with significant counter examples (e.g Sahlberg 2011; 2015) even within the same education system (MacKinnon 2011a)

The journey I have been on in a practice context mirrors that of the conceptual and theoretical nature of the wider systems, far and near. But this has been largely in reverse, as school systems have sought greater control and specification, thus disposing to learnification (Biesta 2009), performativity (Ball 2003), neo-liberalism in education governance (Ball (2015) and the Global Educational Reform Movement (Sahlberg 2011, 2012 and 2015). Knowledge Building operates in different terrain, as I see it. There is a need to articulate this deep divide more specifically, as an immune response (MacKinnon 2011c), giving rise to alternative forms of education system change and reform (and stability in the sense of not changing things which do not need changing) and of evaluation and assessment which are consonant with this philosophy. There needs to be a shift from measurement to understanding, utilising measures as a means to comprehend but not as an end in themselves (see Seddon 2008 outlining systems thinking). To this end I urge a shift of audit and scrutiny from accountability to 'account ability' (MacKinnon 2011a).

Major goals: What we may seek to collectively achieve/accomplish

The session seeks to take the specific examples given, as selected by the presenter who was researcher, action implementation developer and teacher, to explore the 'space beyond' learning. I seek that we collectively further explore or refine the concept of Knowledge Building and its practical applicability through relating concrete examples to the essential motivations and purposes which lay in their formation by pupils/students. In a sense then the artefacts are emergent indicators of Knowledge Building as much they are also the means by which it is enabled. Of necessity Knowledge Building is a fuzzy concept.

In this session I frame attention in order that we may understand Knowledge Building further by examining it through the specific lens of purpose; the purpose being that which arose in these pupils/students as they sought means to articulate, navigate and realise their purposes within the class and school setting (which also occurred off-site as class and school activity). They were their purposes, not mine, even if I was a very active contributor to the context and enablement of opportunity for them to arise. But I did not seek that they should arise, specifically. So much surprised me, which I would see as an oblique indicator of active Knowledge Building. I came to see that this was how the children built motivation and the desire to foster specific skills, awarenesses and knowledge, as a means to enable the purposes which they had constructed. These may be quite local, ephemeral or fleeting. Also they may be repetitive, incrementally building modes of awareness over time through similar repeated actions, slowly changing to match altering development. I came to see that this aspect very much applied to deeper potentials of building informed attitudes or developing specific orientations of personal development, on to higher order thinking and application. The approach also applied specifically to children whom I perceived exhibited characteristics of deficiencies of nurture or organic dispositions of additional support need. Thus a Knowledge-Building approach could reach out to the needs of pupils exhibiting what has been termed 'the attainment gap' but utilising approaches far removed from performativity as have come to be commonly applied and which are entrenching, leading to 'subjectivity as a site of struggle' (Ball 2015).

Focus

The audience is engaged by attention to specific practice contexts through tangible artefacts set by the scholarly context as realised in the conceptual and theoretical underlay of this conference. I make the assumption that those present are familiar with the concept and development of Knowledge Building and its component elements. An aim is to foster discussion of the development of Knowledge Building itself as articulated through the concept of purpose. This is prompted but not constrained by the artefacts. In many pedagogic contexts we hear of the desire to 'get inside' learning. I want to (start to) do something subtly different – to 'get inside' Knowledge Building. This cannot be seen directly but is made apparent, in one respect, through actions as formed with regard to purpose. I see the relationship of Knowledge Building with purpose as two-way and it is that which I explore through discussion in the session, with the artefacts as prompts which guide our way into the thinking and collaborative realisation which formed them.

I also touch on the great divides which operate at the system level, and which require application of modes of Knowledge Building to overcome the barriers which stand in their way, many of those lying within the operational dispositions of education governance and administration, including the directions of school and education 'reform' as widely adopted. By becoming clearer as to what we are enabling and why we may then construct and develop frameworks which protect us as a Knowledge-Building community from destructive 'reform' attempts which undermine our approaches, often unknowingly by those mandating and directing them. The essential fuzziness of Knowledge Building renders it susceptible and vulnerable to modes of educational thought and practice, particularly those arising from centralised planning, specifications, audit and external direction, which threaten or undermine our endeavours to its purposes as articulated by us as a Knowledge-Building community. This is a specific and tangible danger (MacKinnon 2011c). I articulate a distinction between 'accountability' and 'account ability' (MacKinnon 2011a) as a means to harness audit and evaluation to our purpose(s) and transcend this danger, needing also to communicate these shifts of perspective to system change leaders.

Overview of demonstration or other presentation material

Written excerpts including sentences, paragraphs, poems, multi-media artefacts, film excerpts, annotated photographs, webpages, models, films of models, plays, photographs in situ of activities, each exemplifying a Knowledge-Building aspect.

I also state the existence of the above in the context of my own learning journey and particularly with regard to their relevance to the publications below. These form the backdrop of the demonstrative discussion and a hard copy of each is available. The 2017 and 2018 items form a particular focus. Each form part of my own personal learning journey, with colleagues, by which I have come to present this analysis and reflection and from which its examples are drawn. I allude to these, briefly mentioning them in accordance with 'soundbites' as follows:

References of this author utilised with annotated comment

MacKinnon, N., (2011a). The urgent need for new approaches in school evaluation to enable Scotland's Curriculum for Excellence*, Educational Assessment, Evaluation and Accountability*, Volume 23, Number 1. February. (Major reform of education in a specific context cannot occur without giving due attention to the means of getting there, and by extension understanding where 'there' is; that is: evaluation has to contend appropriately with purpose, at all scales. *[academic journal paper]*)

MacKinnon, N., (2011b). 'Let's re-energise 'living learning', *Times Educational Supplement for Scotland. 18 February* (Examining the nature and underlay of 'living learning', the dangers of 'excellence', and proposing an alternative which is relevant to Knowledge Building *[article]*)

MacKinnon, N., (2011c). 'Kills 99% of GERMS' *Times Educational Supplement for Scotland* (11 November) (Understanding the Global Educational Reform Movement or GERM and developing an immune response. *[article]*)

MacKinnon, N., (2015a). Inter-school collaboration: a practitioner perspective, ICSEI 3P breakfast network seminar presentation, 28th International Congress for School Effectiveness and Improvement, Cincinnati, Ohio, USA (Theoretical, practical and conceptual presentation of collaboration between schools as a mode of curriculum practice *[conference presentation as paper and slides with summary journal article]*)

MacKinnon, N., (2015b). Inter-school collaboration: a practitioner perspective, *ICSEI Express and Digest, Volume 6 Issue 2*, The International Congress of School Effectiveness and Improvement *[short article based on conference presentation above]*

MacKinnon, N., (2016). The need for systems thinking to build cultural capacity for innovation throughout school education, Knowledge Building Summer Institute, Singapore. June. (Perspectives on systems thinking as an enabler of cultural capacity for innovation and Knowledge Building *[conference presentation as paper and slides]*)

MacKinnon, N., (2017). Closing the gap from within – reframing assessment through integral understanding, International Congress for School Effectiveness and Improvement, Ottawa, Canada. January (Assessing a single piece of written work through the analytic perspective of Knowledge Building which formed a diagnostic function to this pupil's personal and emotional needs, and which illuminated the context from which these arose *[conference presentation as paper with slides and artefact]*

MacKinnon, N., (2018). *Enabling Purpose as Children's Learning: System Change from the Ground Up*. International Conference for School Effectiveness and Improvement, Singapore (Exploration of synergy and dissonance between school level and national level education policy and resultant practice change.*[conference presentation as paper and slides]*)

MacKinnon, N., and Teo, C.L., (2018). Workshop: *Designing Curriculum, Pedagogy and Assessment to Support Children in Enacting Purpose in their Learning Through Knowledge Building*. International Conference for School Effectiveness and Improvement, Singapore (Comparison of two approaches to curriculum change

related to idea-centred collaborative learning within two countries' education systems set far apart culturally and geographically. *[workshop as abstract and slides]*)

Chapter: 'The Global Educational Reform Movement' in Sahlberg (2011 and 2015) including extended quote from MacKinnon, N., (2011a) (establishing the concept of The Global Educational Reform Movement on the world stage with analysis of its means of establishment and functioning *[book chapter]*)

Conclusion

Learning has no meaning of itself. It only makes sense when matched to purpose. Purpose has to be owned. It cannot be imposed. It can be fostered and inspired. It has to be real, that is authentic. Learning has to reach out beyond its own frame of reference, which means beyond tests and grades, beyond accreditation. Learning matched to sense-making matched to purpose disposes to the creation of knowledge. The fruits of that endeavour are collective and social. They are what make us, as individuals, as organisations, as social entities, as a society and societies, in an ever more connected world. Education is not separate to those, or a preparation. It is inherently a part of Knowledge Building and requires educational institutions – their structures, concepts, values and processes – to so dispose themselves to encompass it. Knowledge Building is demonstrative. It is inherent. It is of the now. It is what it is.

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Notes

Accompanying document: presentation slides of same title
Accompanying materials (not published here): artefacts

How are Ideas Advanced?
: A Multifaceted Investigation of Discourse in Knowledge Building

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Abstract: The present study investigates the classroom and online discourse of a grade 5 science class to trace how scientific ideas were advanced in knowledge building. The data analysis examined the idea content and interaction reflected in the discourse, in terms of language use, interactive patterns, and flow of idea advancement. Specifically, discourse in Knowledge Forum and classroom meeting was analyzed to identify language use and interactive patterns as related to students' idea advancement over time. The result showed that terms and expressions describing research themes were dominantly used. In addition, students playing central roles in the community contributed ideas regarding diverse themes and collaborated with many other students to improve the collective knowledge. Students discussed deeper and wider range of themes by adding and connecting new topics and ideas. They also connected their knowledge with the real-world observations in their school's courtyard. These preliminary findings suggest possible new ways to examine collaborative idea advancement using a combination of linguistic and social interaction measures.

Introduction

The discourse of student-centered collaborative knowledge advancement and creation needs to be investigated to find the important ideas and inquiries and dissemination of the ideas in the community (Zhang, Chen, Chen, & Mico, 2013; Zhang, Lee, & Wilde, 2012). Under the atmosphere of collaborative knowledge building, students "coconstruct/reconstruct shared inquiry structures to shape and guide their ongoing knowledge building processes" (Zhang et al., 2018, p. 390), having the responsibility to improve innovative knowledge, while a teacher acts as a facilitator of students' knowledge advancement (Scardamalia, 2002; Scardamalia & Bereiter, 2003). The improvement of collective knowledge is necessary to be reviewed along with the content and structure of scientific ideas as the discussion progresses.

It needs to trace what and how students discuss and how they cooperate to improve their collective knowledge. For instance, examining lexical items that teachers and students use in class reveals the characteristics of the discourse in a particular discipline (Biber & Barbieri, 2007; Hyland, 2008; Simpson-Vlach & Ellis, 2010). On the one hand, previous studies unveiled the structure of social collaboration between students in knowledge building, such as social process of building knowledge of students and students' contribution to knowledge advancement (Oshima, Oshima, & Matsuzawa, 2012) and students' engagement in discussion (Laat, Lally, & Lipponen, 2007). However, despite the studies on discourse of the collaborative knowledge building (e.g., Matsuzawa, Oshima, Oshima, & Sakai, 2015; Muhonen, Rasku-Puttonen, Pakarinen, Poikkeus, & Lerkkanen, 2017; Tang, 2016; Zhang et al., 2012), few studies researched how the investigation of discourse operates to help teachers and students understand and enhance their learning environment, especially in terms of the use of expanded lexical items and flow of idea improvement in knowledge building.

The present preliminary study was aimed at investigating discourse in a Grade 5 science course over 12 weeks to figure out how students' collective knowledge was improved and in what context. More specifically, this study examined how ideas were advanced in the perspectives of language use, interactive patterns, and flow of idea improvement as students collaboratively engaged in knowledge building discussion. The following questions were addressed in this research:

a) What features of language use and interactive patterns were found in knowledge building discourse?
b) How did students progressively build richer understanding as they incorporated more domain words into their knowledge building discourse?

Data Collection and Analysis

The present study investigated discourse in the knowledge building approach in a grade 5 science class located in the upstate New York. In this class, 21 students discussed, raised inquiries, built theories, and added further ideas to peers' ideas about ecology over 12 weeks. The central themes in the discussion included food chain, bees, animal behavior, plants, and animals in the underground. A teacher taught science in the knowledge building pedagogy for multiple years at this school.

The data was notes posted in the online knowledge building community called Knowledge Forum (KF) and video- and audio-recorded discourse in the metacognitive meeting (MM). A total of 196 notes were obtained—8.91 notes per person and 37.67 words per note on average, respectively. The notes downloaded from the KF were analyzed using a corpus analysis software, *AntConc* (Anthony, 2014) to extract academic words (Coxhead, 1998; Coxhead, 2000) and four-word bundles (Hyland, 2008). After the filtering process, 655 four-word bundles with 285 types were obtained for the KF data analysis. The obtained four-word bundles were coded according to the coding scheme by Hyland (2008), which classifies the bundles into three categories: *research process*; *text content organization*; and *participant stances and engagement* (Table 1). Besides, the interaction between students in the KF was statistically and visually investigated in terms of indegree centrality (receiving comments from peers), outdegree centrality (making comments to peers' notes), betweenness centrality (degree of the central position in the network), and k-cores (the number of the maximal links that all the nodes in a subgroup have with other nodes) (Hanneman & Riddle, 2005) by employing *UCINET* software (Borgatti, Everett, & Freeman, 2002) and *SPSS* (IBM Corp., 2010). Besides, a selected episode of the MMs was transcribed and qualitatively analyzed to trace the flow and structure of ideas advancement.

Table 1: Coding scheme for categorizing word bundles (adopted from Hyland's study in 2008)

Category	Definition	Example
Research process	To describe elements regarding research	· Location – presenting time or place (*in the food chain*) · Procedure (*carried to other flowers*) · Quantification (*a lot of the*) · Description (*a region known as*) · Topic – related to a field of research (*both plants and meats*)
Text content organization	To indicate the use of textual elements and organize text	· Transition signals (*but they get there*) · Resultative signals (*thus making their own*) · Framing signals – limiting the situation for argumentation (*it is like a*)
Participant stances and engagement	To describe the point of views of students and their engagement	· Stance features – writer's or speaker's point of views (*I am also wondering, I'm pretty sure*) · Engagement features – reader's or listener's engagement (*and you can find, we take in oxygen*)

Note: This coding scheme was also utilized in the conference paper by Park and Zhang (2018).

Preliminary Findings

How are ideas advanced?: Language use and interactive patterns

Table 2 presents the frequent academic words discovered in the KF notes: *consumers* (19 times); *theory* (16); *adapt* (11); *primary* (9); *energy* (8); *process* (5); *final* (4); *job* (3); *link* (3); and *unique* (3). These words were mostly used when describing the research topics. In particular, *consumers* were used when discussing the structure of the food chain and often associated with *primary* and other terms expressing orders (e.g., *secondary*, *tertiary*, *quaternary*) to explain the system of the food chain.

Table 3 shows the functions of the four-word bundles. The four-word bundles were dominant in the category of illustrating the research process in the KF, accounting for 82.81 percent of the total. Participant stances and engagement-oriented bundles were 8.77 percent, and text and content organization-oriented bundles were 8.42 percent. This finding indicates that the discussion mainly proceeded with regards to ecological subjects in the online learning community. When it comes to the frequent four-word bundles in the KF (see Table 4), the student often used *I need to understand* (36 times), *my theory is that* (7), *I just learned that* (6). Some other word bundles were also related to the discussion topics (e.g., *the little brown bat*, *the star-nosed mole*, *in the food chain*). This result implies that students focus on the themes that they currently discuss and want to build on. One thing that needs to be noted here is that the prominent word bundles in the KF included the scaffolds that students can use when writing their notes. For instance, *I need to understand* was generally used when the students raised an inquiry about what they were researching or pointed out the knowledge that they felt they needed to went deeper (e.g., *I need to understand how plants absorb the ingredients*). Also, *my theory is that* was utilized to present a statement with the students' own logic and ideas (e.g., My theory is that *maybe they keep their food near them at all times. Like maybe a bird keeps their food near their nest*). Nonetheless, using these expressions structured the sentences with students' ideas in their notes, helping them identify focal ideas that they needed and wanted to explore.

Table 2: Frequent academic words in the KF

Academic words	Frequency
consumers	19
theory	16
adapt	11
primary	9
energy	8
process	5
final	4
job	3
link	3
unique	3

Table 3: Functions of four-word bundles in the KF

Functions of word bundles	Percentage (%)
Research process	82.81
Participant stances and engagement	8.77
Text and content organization	8.42

Table 4: Frequent four-word bundles in the KF

Four-word bundles	Frequency
I need to understand	36
my theory is that	7
I just learned that	6
the little brown bat	5
back to the hive	4
different kinds of dirt	4
the star-nosed mole	4
in the food chain	3
learned that some insects	3
a bee lands on	2

Furthermore, the interaction between the students in the KF was investigated, focusing on indegree centrality, outdegree centrality, betweenness centrality, and k-cores. The Spearman's rank-order correlation between the four variables was tested to investigate the students' performances in knowledge building, while controlling for the number of the notes that each student posted in the KF. As a result, Table 5 shows that there are statistically significant correlations between indegree centrality and outdegree centrality ($r_S(18) = .452$, $p < .05$), indegree centrality and betweenness centrality ($r_S(18) = .518$, $p < .05$), indegree centrality and k-cores ($r_S(18) = .740$, $p < .01$), outdegree centrality and k-cores ($r_S(18) = .482$, $p < .05$), and betweenness centrality and k-cores ($r_S(18) = .451$, $p < .05$). This result indicates that a student who received many responses from peers made many comments on peers' ideas. They also tended to be in the central position as a broker to connect many other peers in the network. In particular, a student acting as a broker exchanged ideas with a large number of the peers.

Figure 1 demonstrates the visualized network of the students' interaction in the KF. In this network, a node indicates a student. A link between students refers to making comments on each other's notes, while an arrow indicates the direction of responses. In addition, the color of a node shows different k-cores—red is 3-core, green is 2-core, blue is 1-core, and black is when there are no links. As a result, nine students (S1, S2, S4, S5, S7, S8, S11, S14, S19) were found in 3-core group, seven students (S10, S12, S13, S15, S16, S18, S21) in 2-core group, and three students (S3, S17, S20) in 1-core group. S6 and S9 did not have any connections with other students. Consequently, students in the 3-core group showed the highest coreness value, and each of them exchanged their knowledge with at least three other students in this learning community. Of those in the 3-core group, S5, S7, and S8 showed the highest betweenness centrality.

In the case of S8, in particular, he studied a variety of topics about ecology, leaving his comments about most of the main topics such as animals in the food chain, behavior of animals, underground, and plants. In most of his notes, he built new facts and his theory on peers' ideas. Besides, S5, who had the highest betweenness centrality, researched and discussed animals living underground. An interesting feature about the way of his remarks in the KF was that he complimented peers about their insightful opinion and then added his opinion with the new knowledge to build on others' thoughts. He stated even opposite opinion against other's opinion and raised questions with the new information. Moreover, he asked peers to add further knowledge to his idea and asked for the information about the source. Namely, he used diverse strategies to interact with his peers to advance the collective knowledge. Overall, not only the ideas in the notes of the students but also the way of their interactive ideas progression were critical to investigate students' contributions to the learning community and their collaborative idea advancement.

Table 5: Correlations between students' indegree, outdegree, betweenness centralities, and k-cores

	Indegree centrality	Outdegree centrality	Betweenness centrality	K-cores
Indegree centrality	1			
Outdegree centrality	.452*	1		
Betweenness centrality	.518*	.375	1	
K-cores	.740**	.482*	.451*	1

Note: The number of the notes each student posted was the controlling variable. * $p < .05$; ** $p < .01$ (2-tailed)

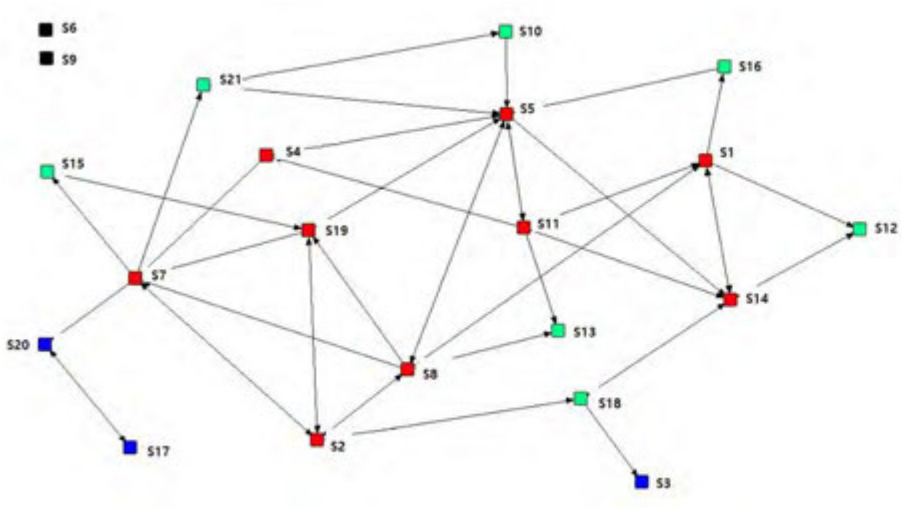

Figure 1. A visual network of the students in the KF. A node indicates a student, while a line means there is an interaction between two students. An arrow shows the direction of building on a note of another student. The color of a node presents k-core where a node belongs—red is 3-core, green is 2-core, blue is -core, and black is when there are no links.

How are ideas advanced?: Flow of connecting and expanding ideas

In order for the deeper comprehension of the students' idea advancement, the face-to-face discourse was examined. Figure 2 shows the flow of idea improvement in an episode of the MMs, demonstrating the terms about *creatures* which constitute the *ecosystem*. A bar chart indicates the time flow of mentioning each term in the discussion, and a vertical line points out the time when the term was stated. The bar charts are organized in accordance with the initial moments of each term's first appearance in the discourse; for instance, *creatures* was mentioned first while *mold* was said lastly in the discourse.

This discourse began with the broad concept like *creatures*, and the scope of the discussion topics was getting wider and deeper as the students brought new concepts and made connections between the topics and their observation in the school courtyard. The teacher kept facilitating the overall discussion to encourage the students to build on peers' remarks and connect their ideas with others'. She also commended the students for their contributions to the learning community with personal experience and connections with peer's ideas.

In this MM, the students started their discussion with an inquiry about how *creatures* live on the ground. They initially focused on *worms* which S3 was researching and then connected the components for building the condition related to *worms*' breathing. The teacher asked S3 to select a peer who would build on, and the community expanded the discussion topics such as *air*, *soil*, *water*, *light*, *heat*, and *sunlight*. As the conversation proceeded, the teacher asked S8 to expand the discussion with another topic, and S8 brought the new concept called *food chain*. Referring to what S9 stated, S8 elaborated the interaction between *soil*, *worms*, *flowers*, and *bees* and created an idea that all the components in the *ecosystem* have connections under the umbrella term, *food chain*, as in the example [1]. He further explained the layers of the *food chain* along with *producers* and *consumers* (e.g., *primary consumers*, *secondary consumers*). The teacher enhanced the discussion about the *food chain* to be reflected in students' research in the *courtyard* of the school before this MM. The teacher asked S8 to make connections his understanding about the *food chain* with his observation in the *courtyard*. Like in the example [2], the teacher asked the students a question about who the primary *producers* are in the *courtyard*. After then, the students co-generated answers to the inquiry by mentioning *plants* and collaboratively built on the ideas with the addition of *worms*, *birds*, and *eagle*. *Worms* was continuously mentioned throughout the discussion, and *soil* and *dirt* were restated when talking about *flowers*, *bees*, and *food chain*.

[1] S8: So, I'm going with *food chain*. Like what S9 said, like worms interact with *soil*, and *soil* interact with *flowers*. *Flowers* interact with *bees*, and so on. So, it's kind of connected to what under *food chain*.
T: S2, you have something more about *food chain*? Maybe, you can build on what you were saying? What you have studied.
S8: Well, there's like… well, I think like for a lot of different things there's elements, and there's a lot of different elements in *food chain*. I have tried that so far. There's three main ones, the *producers*. Well, there's always bottom of the *food chain*.

[2] T: Who are the *producers*?
S8: So, the *producers* here would probably *plants* in the *courtyard* out there. The primary *consumers* would probably…
T: *Worms*?
S8: Yeah, maybe *worms*. And then the secondary *consumers* could be *birds*.
T: Uh-huh. Eating the *worms*? Okay.
S5: But there's something probably eating *birds*. And then, it will go up to the very top further, and then…
S8: Like the *eagle*.
S5: Yeah. It's kind of like *mold* can also eat *worms*. So, it's multiple lines, I'm sure.
T: Okay. What's interesting about *food chain*? That there are connections between everything?
S8: Yeah.

Conclusion

The present research investigated how scientific knowledge was advanced in collaborative learning discourse. The discourse in the KF was examined regarding academic words, four-word bundles, and interactive patterns. The flow of idea advancement in the face-to-face discussion in MM was also traced.

As a preliminary result, terms and expressions describing research themes and mentioning scientific ideas that the students wanted and needed to build on were dominantly used in the KF. The students receiving many comments more often replied to peers' ideas and played central roles to make connections between other students in the community by sharing the ideas about various topics with many other students. The qualitative investigation of the discourse in the MM ascertained that the central students made prominent contributions to the discussion by linking diverse topics and building advanced ideas. The students developed the discussion as broadening and deepening the scope of the discussion themes. Further, they made connections between their understanding of the discussion themes with the real world subjects, for instance, what they observed in the school courtyard. The teacher acted as a facilitator to enhance the students' idea improvement (Scardamalia, 2002; Scardamalia & Bereiter, 2003). To conclude, the investigation of the flow and structure of discussing scientific ideas and interactive patterns enabled the comprehensive understanding of the students' collaborative knowledge advancement. The further study may need to examine the stream and configuration of collective idea advancement in a bigger and broader range of picture as well as with more sophisticated exploration of the critical moments of idea improvement.

Figure 2. The flow of idea advancement in the MM about creatures in the food chain. A bar chart indicates the time flow of mentioning each term in the discussion, and a vertical line points out the time when the term was mentioned. The bar charts are organized by the initial moments of each term's first appearance in the MM.

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Acknowledgments

This research was sponsored by the National Science Foundation (IIS #1441479). We thank the teacher and students for their creative work enabling this analysis.

Emerging concepts for co-designing technology for dialogic practices – the case with Talkwall

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Abstract: Talkwall is a microblogging service designed to be a companion for teachers who want to increase the quality of talk in their classrooms. Talkwall draws on educational insights into the role of dialogues in critical thinking and knowledge building.

The challenge we address in this paper is the gap between theories of dialogic teaching and technology support on the one side and how teachers can be involved in design and development of tools that can have an impact on dialogic practices in classrooms on the other.

Design-based research has been the method for involving teachers in this work, and we explore a concept driven approach to improve the exchanges between theory, design, and practice. Five bridging concepts emerged in the co-design of Talkwall.

Introduction

Talkwall can best be described as an enclosed social media platform for the classroom, and may benefit from established social media practices teachers and students bring to the classroom. Talkwall draws on contemporary technologies, such as micro-blogging (e.g. using only short messages to communicate like Twitter) and uses this to encourage students to engage and share their developing ideas, in turn promoting positive dialogic interactions.

The aim for the research has been to identify intermediary knowledge in the form of bridging concepts that can (i) guide the design articulations of educational technology, (ii) enable teachers to participate in design and exploration of a new tool, and (iii) contribute to knowledge about emerging and technology mediated dialogic practices.

Introducing Talkwall was an essential part of a training and practice development program in six Norwegian and UK schools, across three subjects. The program included 21 teachers as co-researchers who contributed to design and experimentation of Talkwall in their classrooms with a total of 300 students during the spring of 2017.

During the design of Talkwall, teachers have acted as co-researchers by tailoring pedagogic approaches to subject discourses, trying, exploring and developing new classroom practices, forming new tasks and activities and adapting Talkwall and resources to their own needs. Theorizing will thus relate strongly to real-life classroom contexts, and design principles and models will 'reflect the conditions in which they operate' (Anderson & Shattuck, 2012).

Background

There is strong consensus that high quality educational dialogue among peers is associated with positive learning outcomes, and engaging children in extended talk which encourages them to 'interthink' and reason together in talk, impacts both their subject learning, and general reasoning skills (Knight & Littleton, 2015).

We have adopted microblogging to support dialogue and knowledge building in a classroom setting. It may be argued that microblogging has similarities to Papert's approach of constructionism in the sense that it may be grounded in a tradition that emphasizes the learner's active participation in the learning process. It should be noted that the design of Talkwall is in line with Scardamalia and Bereiter (2010)**,** as more emphasis is placed on intentionality and on the collective purpose of knowledge building compared to microblogging in general.

A knowledge-building community aims at creating new products such as ideas, explanations, or theories that support members of the community in understanding their environment. The challenge of fostering knowledge building is not to control the self-organizing process as some instructional approaches attempt to do, but to facilitate the emergence of higher-level outcomes, e.g., better explanations and/or more coherent understanding (Scardamalia & Bereiter, 2014). This has parallels to notions of exploratory talk (Wegerif, 1996) and research on critical thinking (Mercer, Hennessy, & Warwick, 2017).

Method: Design-based research for involving teachers

The design of Talkwall is part of a larger research project DiDiAC, in which we have developed and tested methods for improving the quality of classroom interaction amongst teachers and students partly by developing and experimenting with digital resources.

Our work is grounded in design-based research (DBR) as it informs the development of ‘products’, design principles, and models, employing theory and research findings in combination with iterative use in real settings; data collection; analysis and evaluation; re-design and adaptation (Anderson & Shattuck, 2012). In particular, we are concerned with how technology may be designed to broaden participation in the classroom, and how technology may increase the quality of talk in the classroom. We have based or approach to DBR on a collaborative partnership between teachers, researchers and technology developers (Roschelle & Penuel, 2006) and is a result of a long-lasting relationship with teachers in situated, local teaching practices, where we have experimented with future teaching and learning, introducing various Internet and Web2.0 based services (Lund & Rasmussen, 2008).

Here, we will focus on emerging design principles, and develop new theoretical insights about how technology can be designed to foster learning and teaching. Design-based research has been criticized for being vague when it comes to translations from theoretical understanding to practical solutions in the classroom (Phillips & Dolle, 2006; Sandoval, 2014). Further, McKenney (2013) argues that in-sights on pedagogically appropriate uses of educational technology for representative teachers in everyday school settings are severely limited, and that there is a problematic gap between what could be effective technology-enhanced learning (TEL) in theory, and what can be effective TEL in practice. This gap is partly because DBR is often conducted at the bleeding edge of what is technologically possible exploring innovative uses of new and emerging technologies, while insufficient research and development work focuses on what is practical, today (McKenney, 2013, p. 1).

The main roles for teachers have been to take part in series of design workshops (ideation and prototyping), take part in interventions with Talkwall and other resources in the classrooms (enactment of new technology), and evaluating the teaching and learning outcomes mindful of the role of technology (based on peer and self-reflection). The role of teachers in our DBR approach lend ideas and principles from Scandinavian participatory design traditions (Bødker, Ehn, Sjögren, & Y Sundblad, 2000; Bødker, Grønbæk, & Kyng, 1995). Teachers are empowered to orchestrate innovative learning experiences among children in their everyday educational contexts by rehearsing future practices (Binder et al., 2011) with emerging technology. Our design approach is not only attentive to fine-grained issues of pupil learning and instruction but also to “broader factors that determine if and how innovations are understood, adopted and used by teachers and schools, by designing innovations to align with their zone of proximal implementation” (McKenney, 2013, p. 2).

Theoretical framework: Bridging concepts

We have borrowed ‘bridging concepts’ from the field of human computer interaction (HCI) to bridge the gap between theory and practice in design-based educational research. This deserves some explanation before we present the particular bridging concepts that emerged in the course of the design of Talkwall.

Stolterman and Wiberg (2010) explore a concept-driven approach to interaction design research with a specific focus on theoretical advancements. Concept-driven design research is explorative in nature, aiming at manifesting visionary theoretical ideas in concrete designs. The idea is to bridge the gap between generalized theories and design instances with ‘intermediary forms of knowledge’ in the form of conceptual constructs. Höök and Löwgren (2012) extends these ‘conceptual constructs’ in their work on ‘strong concepts’. Strong concepts are proposed as design elements abstracted beyond particular instances which have the potential to be appropriated by designers and researchers to extend their repertoires and enable new particulars instantiations. This idea is furthered in an educational context by Prieto, Alavi and Verma (2017), suggesting ‘strong TEL concepts’ as a way to bridge the gap between theory and practice in DBR, as is our concern as well.

Our approach differs both from ‘conceptual constructs’ and ‘strong TEL concepts’ by following an argument by Dalsgaard and Dindler (2014), developing an alternative concept-driven approach they label ‘bridging concepts’. They argue that ‘conceptual constructs’ and ‘strong concepts’ are two forms of knowledge that represent opposite positions, as strong concepts are primarily developed bottom-up or inductively with the main purpose of generating knowledge that can be employed in design practice, whereas conceptual constructs are primarily developed top-down with the main purpose of enriching the theoretical foundations of HCI (p. 1636). They propose bridging concepts as distinguished by their ability to facilitate exchange both ways between overarching theory and practice, rather than by being developed from theory or practice or with the specific aim of informing either theory or practice (p. 1637). Bridging concepts inhabits the middle ground between theory and practice and bridge and span the gap between theory and practice and thereby unveiling and articulating untried design opportunities and potential theoretical advancements.

Results: Five concepts central for the process and communication with the teachers

Concept #1: A **contribution** is a microblog, a digital representation of an idea. In Talkwall, a contribution is short, currently limited to 140 characters. This short format is chosen to enhance oral interaction, and not substitute it. To allow the users more interactional control than what is often the case in other microblogging environments (e.g. Twitter) contributions are implemented by a card design. A contribution can be built on by someone else (e.g. extended, made more precise, etc).

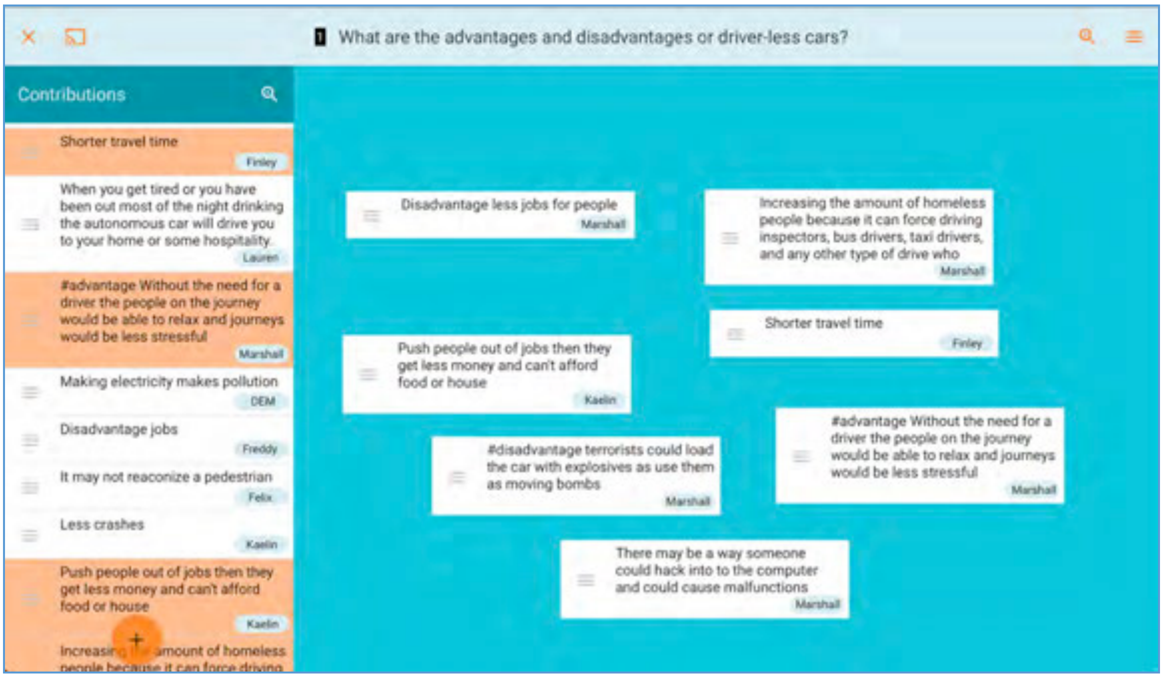

Figure 1. Talkwall with the feed at the left, the wall in the middle. The task is displayed at the top.

Concept #2: The **feed** provides mutual awareness of ideas. The design draws from omnipresent discussion threads online, such as comments beneath news articles and blog posts, Twitter and Facebook feeds, discussion forums and similar. The blend of oral and digital contributions is central to Talkwall, and the feed provides awareness of participants' thinking, rather than a thread or sequence of ideas. The feed in Talkwall is shared on all participants' devices, as well as the teachers' screen, and offers means for students to effectively share their contributions with their peers. The feed is an awareness mechanism that may be used by students to acquire ideas from others and for the teacher to acquire both detailed information about how students are formulating their ideas, the sequence and emergence of ideas, and an overall idea of the dialogue in the classroom as a whole.

Concept 3: A **wall** allows for contributions to be promoted from the feed and be represented in a spatially organized surface. The feed and the wall are two different lenses to the contributions, the feed focuses on the temporal and emergent nature of ideas, while the wall is a means for selecting relevant contributions, and allowing spatial arrangement by means of direct manipulation of contributions in order to make connections, to aggregate and classify contributions, and to amplify means for synthesizing.

Concept #4: 'Contribution', 'feed', and 'wall' are concrete expressions of, and nested concepts within the forth concept, a **dialogic space**. Dialogic space, inspired by Wegerif (2015), is a key to the design of Talkwall, as dialogue is mutually constructed by oral and digital contributions in the classroom. This hybridity poses new challenges both in how we understand the roles of technology in the digitalized classroom, but also in terms of how technology can be designed. By means of Talkwall, diverse voices are represented, made accessible over time, enabling the class to invoke and combine ideas, and to keep them alive in the dialogue.

*Concept #5: '***Companion'** has emerged from collaboration with teachers, and their own formulations of how they cope with new digital tools and materials in the classroom (Rasmussen & Lund, 2015). In Talkwall, the role of the teacher has been a key point in the design, and has promoted some privileges in the tool for teachers, such as access to all the participants' walls and ability to show any one of them on the shared screen in from of the class. Further, there are features that support the teacher as a leader of the dialogue, such as means to formulate tasks and to manage Talkwall sessions.

Summary and further research

Drawing on Dalsgaard and Dindler (2014), these five concepts worked as 'bridges' between theory and practice, and emerged as intermediary knowledge in the communication and material interactions with the teachers.

What the notion of bridging concepts enable is exactly the communicative work that is needed in the design work that aims to tailor a material product to a specific educational practice and drawing also on theoretical insights from this field of practice, i.e. dialogic theory.

We argue the bridging concepts facilitate exchange both ways between theory and practice, and that the material outcome of the design incorporates and displays the ideas for future practice, and as such it contains the embryonic starting point of what 'might be' (Lund, Rasmussen, & Smørdal, 2012). Since ideas of what 'might be' are often volatile and hence hard to hold on to, teachers may find valuable a tool that inscribes significant aspects of dialogic theory and may be a 'digital companion' with potentially transformative impact for emergent dialogic practices.

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Exploring the contribution of students with learning difficulties in an inclusive co-invention project

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Abstract: This study investigates the contribution of students with learning difficulties (LD) in a co-invention process where a student team (Grade 6) generated ideas, constructed their own inventions, and evaluated the functionality of the inventions in close collaboration with their team members. In this preliminary analysis, we report on the experiences of three LD students when working in a 'gel comb' invention team. According to the interview data, the students viewed the project as beneficial. Two main themes emerged from the preliminary qualitative content analysis: peer- and teacher-supported collective responsibility and the relevance of the invention for shared agency.

Introduction

Inclusive education, where students with identified learning difficulties (LD) learn as full members of the group, has been one of the central aims of educational polices since the Salamanca Statement (United Nations Educational, Scientific, and Cultural Organization, 1994). In Finland, The Basic Education Act (642/2010) obligates schools to organize educational support for students' growth, learning, and school attendance, including students with mild and severe LD. In fact, intensified or special support was received by 16.4 percent of comprehensive school students in Finland in autumn 2016 (Official Statistics of Finland, 2017). Recent studies have indicated that many teachers face problems when implementing inclusive education in classrooms both in Finland (e.g. Paju, Räty, Pirttimaa, & Kontu, 2015) and in other countries (Bešić, Paleczek, Krammer, & Gasteiger-Klicpera, 2017). In addition, there are worrisome observations that LD students are generally less accepted by their peers, which has a negative effect on their self-concept (Pijl & Frostad, 2010). However, the pursuit of meaningful learning challenges and mutual peer support facilitates and engages LD students in learning (Scruggs, Mastropieri, Bakken, & Brigham, 1993). Some investigations indicate that students with diverse styles of or orientations towards working often collaborate productively, and this may provide an encouraging example to LD students (Tomlinson et al., 2003). Pedagogic support that is responsive to learners' varying readiness, interest, and skills is needed (Brigham, Scruggs, & Mastropieri, 2011; Tomlinson et al., 2003).

The basic tenet of our investigation is that LD students can productively participate in knowledge-creating learning practices (Hakkarainen, 2009; Paavola & Hakkarainen, 2014) in terms of taking part in learning and knowledge-building efforts and the associated peer collaborative processes. In knowledge-creation practices, every team member is encouraged to contribute their knowledge to the shared epistemic object (e.g. Damsa et al., 2010; Hakkarainen, 2009). In addition, LD students may take part in a knowledge-creation process and assume collective cognitive responsibility for developing their joint object of inquiry. This entails every student, including LD ones, contributing to knowledge improvement (Scardamalia, 2002). The involvement of students with special educational needs is an important aspect of democratizing knowledge; by taking part in a joint knowledge-creation process they may gain a strong sense of contribution and earn social recognition for their achievements. Knowledge-creation is a nonlinear and emergent process (Scardamalia & Bereiter, 2014), which means LD students may need a great deal of support and structuration. This does not, however, mean going back to closed, linear, and scripted learning processes, but rather involves providing real-time support and scaffolding according to the emergent situational needs (see also Viilo, Seitamaa-Hakkarainen, & Hakkarainen, 2017). The purpose of the present study is to investigate LD students' experiences of participation in knowledge-creation based co-invention challenge, and to contribute to this area of research. The research questions are: 1) What were LD students' views of their contribution to the co-invention process? 2) How was the LD students' contribution supported in the co-invention process?

Method

Research setting and participants

The co-invention project was organized in two cycles in spring 2016 and spring 2017 in a primary school in the capital area of Helsinki, Finland. Forty-two sixth graders, aged 12 to 13, participated in the project. The co-invention challenge, with the theme Everyday Activities, was designed by a team of teachers (two class teachers and one special education teacher) and researchers to integrate science, craft, arts, mathematics, and history content. The actual design task for the experiment was based on the student teams' analysis of daily activities and everyday tools. Students were asked to improve a tool or to invent a new one to make the daily activity easier. Their aim was to design an intellectually challenging, aesthetically appealing, and personally meaningful complex artefact that integrated physical and digital elements (e.g. circuits or robotics). The students formed 13 teams to work on their inventions. Table 1 presents the structure of the co-invention project.

Table 1: Schematic structure of the co-invention project.

	Spring 2016; Cycle 1	
Phase	Description of activities	Duration
Orientation	Students analyzed existing artefacts and their uses with a real-life expert designer, made notes, and became familiar with design processes.	1 session; 90 minutes
Skill building	Students practiced using various technological tools, and techniques (21st Century note booking, coding with Lego robotics, and GoGoBoard) were presented.	3 sessions; 90 minutes each
Co-design brief and design constraints	Students brainstormed the ideas in groups in school and with parents at home. Students grouped the ideas and defined users, needs, and functions.	2 sessions; 90 minutes each
Science practices	Students evaluated the properties and behavior of the materials and designs used in similar artefacts.	1 session; 90 minutes
Design practices	Students analyzed the design constraints related to material properties and structural and functional features. Student teams presented their ideas and plans to the whole class, and received peer feedback through an electronic form.	1 session; 90 minutes
Knowledge seeking	Students made visits to off-school sites to gather information and to familiarize themselves with materials not available in the school.	Half-day trip; approx. 120 minutes
Experimenting	Students explored and experimented with their design solution and with the physical properties of its materials (e.g. durability, insulation, structural stability, functional adequacy).	2 sessions; 90 minutes each
MakingLab	Students constructed models (from paper, clay, etc.) and experimental prototypes (mock-ups).	3 sessions; 90 minutes each
Exhibition	Student groups created poster, PowerPoint, or video presentations to share their designs with an audience (parents).	60 minutes
	Spring 2017; Cycle 2	
Orientation	Students analyzed the inventions they had produced the previous spring. Students made plans for alterations and the required science and design practices.	1 session; 90 minutes
Skill building	Teachers explained how to use the class's digital learning environment for collaborative knowledge building.	½ session; 45 minutes
Experimenting and MakingLab	Students shared ideas, explored and experimented with their design solution, and constructed prototypes.	8½ sessions; 90 minutes each

	Spring 2016; Cycle 1	
Phase	Description of activities	Duration
Exhibition	Student groups created poster, PowerPoint, or video presentations to share their designs with an audience (other inventors, teachers, university staff).	120 minutes

The present investigation focuses on examining one team and gathering the participating LD students' views at the end of the process. The team was chosen because of its participant structure (two mainstream and three LD students). Their invention was a gel comb for boys who want to gel their hair quickly without getting their hands dirty (Figure 1). The gel comb looks like a normal comb, but it has a container in which the gel is stored and then pressed through comb spikes and into the hair. The team made five different prototypes from wood (black in Figure 1), recycled materials (yellow, green, and blue), and 3D printing (white).

Figure 1. Prototypes of the gel comb.

Data collection and analysis

Before the second cycle in spring 2017, the teachers' perceptions of LD students' learning was reviewed during video-recorded sessions. All of the gel comb team members (Elias, Juhani, Leo, Mikael, and Olavi) were interviewed individually at the end of the project in May 2017. Structured interview guidelines were drawn up, including general and follow-up questions based on three themes: background (general opinions on learning, technology, and team work), invention (depiction and process), and team work (group organization and reflection). The corresponding author conducted the interviews on a one-to-one basis following the stimulated recall method. We applied Tochon's (2007) notions on viewing past events to remember one's past thoughts using the notes, and photos, taken by the team during the project lessons as a stimulus to help them recall. In order to collect high-quality data from the LD students, it was essential that the researcher knew them well (Stake, 2005; Stalker, 1998). The corresponding author was present at every session; this familiarity increased confidence among the LD students (Stalker, 1998).

Table 2: Analyzed students' ages, learning difficulties at school, attitude to team work, and transcribed interview data (in number of words).

Student (pseudonym)	Age	Teachers' view of learning at school	Attitude to team work	Data
Elias	12	Diagnosed with mild mental retardation. Difficulties appear as slowness, reluctance to work with strangers, and a tendency to retreat.	Difficulties in naming positive or negative aspects of team work. Likes to work in a team if other members are familiar to him.	2316 words

Juhani	12	Mainstream student	Likes to work in a team because it is more productive. Working with familiar persons is easier for him.	1990 words
Leo	12	Mainstream student	Likes to work in a team because tasks are shared. Often organizes tasks among team members.	2906 words
Mikael	13	Diagnosed with ADD (attention deficit disorder without hyperactivity). Difficulties appear as needing teacher support, the teasing of others, and ignoring school duties.	Likes to work alone rather than in a team because it is easier to concentrate when working alone.	2325 words
Olavi	13	Diagnosed with ADHD (attention deficit and hyperactivity disorder). Difficulties appear as a lack of concentration.	Likes to work in the team but feels that sometimes it is difficult to participate. Feels that in a team it is easier to get help and use own strengths.	2604 words

At the beginning of the data analysis, the description of participating students was drawn up based on the interviews with teachers and students (Table 2). The recorded interview data was transcribed and coded using the Atlas.ti software. In this preliminary analysis, we decided to focus closely on the LD students in order to understand their needs and experiences better. The mainstream students' data was also analyzed, but not as thoroughly as that relating to the LD students, which was systematically analyzed using theory-based coding. The categories 'collaboration,' 'LD support,' and 'co-invention process' were defined beforehand, based on previous research literature (e.g. Brigham, Scruggs, & Mastropieri, 2011; Johnson & Johnson, 2013). During the coding process, the categories were refined into three main categories of 'collaboration,' 'competences,' and 'invention,' including nine sub-categories and forty codes. In Atlas.ti, we ran the basic analyses of codes and their co-occurrence. In what follows, the preliminary findings are presented together with illustrative quotations from the interviews. Two main themes emerged from the data analysis: peer- and teacher-supported collective responsibility and the relevance of the invention for shared agency.

Preliminary findings

Peer- and teacher-supported collective responsibility

All students had a positive attitude to team work (Table 2), and the interviewees mentioned that shared responsibility was its most beneficial element. Almost everyone thought that working with friends of other familiar people was easier for them. However, the LD students had different general opinions on their collaborative learning activities. Elias felt that working in a team was easy, especially if he was working with a friend who he knew beforehand. However, Mikael thought he concentrated better when working alone, and said that focusing on a task was difficult if he had a friend in the same group. Olavi felt that participating was sometimes challenging if the other team members were ignoring him or if he did not know how to participate. Even though the LD students' general opinion of collaborative activities at school differed, their experiences of this co-invention project were only positive. Inside the team, students formed three work pairs. Olavi helped Leo to organize the group's tasks. When everyone knew what to do, Olavi and Leo worked on different areas based on whatever needed to be done. Mikael made prototypes with Juhani, and Elias drew sketches of different prototypes. In general, all three LD students felt that collaborative learning was easier for them because of the shared responsibilities involved and the ability to utilize each member's strengths.

Throughout the interviews, all students talked of 'we' instead of 'I' when describing the co-invention process. In general, the mainstream and LD students had different views of organizing the work at the beginning of sessions. The mainstream students saw that they shared tasks and made decisions collaboratively. For example, Juhani said that 'we always discussed what we should do. If we couldn't decide or divide tasks ourselves, [the] teacher helped us.' Leo pointed out that his role was 'to take care of dividing [the] tasks,' and mentioned the teacher's role in supporting the team. For him, knowing that the teacher's support was available was enough. Indeed, the mainstream students mentioned only teacher support, and never peer support, while the LD students felt they benefitted from peer and teacher support, although peer support, and especially Leo's support, was mentioned more often than that of teachers.

> Interviewer: What kind of help did you need and get?
> Olavi: I got guidance [on] what to do, and [on] what the general idea of it was [the invention].
> I: Who gave you guidance?
> O: The teacher, Leo, and Mikael. And then Juhani and Elias gave some more.

The group roles that Leo set at the beginning of each session seemed to be beneficial for all LD students. The clear group roles appeared multiple times, together with the codes 'decision making' and 'dividing tasks.' It seems that the clear group roles made cooperation feel easier, which was relevant for the LD students' collective responsibility. All of the LD students experienced working alone as being more difficult for them. For example, Elias thought that when 'working with familiar persons, the learning tasks are much easier. It gets more difficult if I'm working alone.' Olavi on the other hand described the benefits of team work: 'You get support and you can help others in tasks in which you are good.'

It was evident that the gel comb invention team had a recognizable leader. In addition to organizing team work, Leo was the dominant member, with the ability to form a clear picture of the design ideas, participate in all tasks, and spur everyone to contribute.

> Interviewer: How did you get to these solutions?
> Mikael: Don't ask me, ask Leo.

Inventions as drivers for shared agency

During co-occurrence analysis, we identified the importance of the shared object for all of the LD students. First, most of the quotations in the data were invention related; the clear group roles, support, and productive work co-occurred multiple times in describing the invention. Differentiated tasks, the necessary support, and the ability to contribute seemed to be committing factors for the LD students. Although Leo was named as orchestrator, all interviewees knew how the gel comb was supposed to work; they were also able to explain the difficulties they faced when building the actual mechanism. All of the LD students felt that the malfunctioning invention was a success rather than a failure.

> Olavi: We made a prototype at least, and we did our best.

The mainstream students talked more about the malfunctions of the invention and reflected on what the group could have done differently. Juhani explained that 'sometimes we just chatted and goofed around…we didn't get anything at all done.' Leo had a similar view, as he thought that the team 'worked well sometimes and [at] other times poorly.' Overall, Leo thought they 'had a lot of fun working together…We could have succeeded better with [a] different group. Now we just thought that this is fun.'

Competence-related issues were also identified from the LD students' interviews, where invention co-occurred with attitudes to working and working skills several times, especially in terms of problem-solving and decision-making skills. In addition, shared agency was noticeable when the LD students talked about their role in the process (see above). This knowledge-creation project engaged all of the LD students in learning. Olavi and Mikael also considered it beneficial for their future.

> Interviewer: What have you learned in this invention project?
> Olavi: That it is worth [putting] effort [in] to do things.

Conclusions and discussion

The purpose of this study was to investigate whether LD students can productively participate in a knowledge-creation based co-invention project. We attempted to respond to findings from previous studies where schools had difficulties in implementing inclusive education (e.g. Paju et al., 2015; Bešić et al., 2017) and promoting peer acceptance in inclusive classes (Pijl & Frostad, 2010). Our preliminary analysis provides promising insights into LD students' productive participation when working on a shared epistemic object (Hakkarainen, 2009). In the gel comb team, the innovation was a driving force for all students. However, the need for support was evident, especially in terms of the LD students having a clear role in the team and the commonly recognized leader-enabled positive and genuine social participation. From the LD students' point of view, the co-invention challenge improved their attitudes towards collaborative tasks. Furthermore, in this investigation, the mainstream students focused on 'invention' instead of the LD students' disabilities. Working as full members of a group could promote LD students' social acceptance by peers, and therefore promote inclusion.

The need for differentiation is prominent with LD students. Our study increases the understanding of at what point of the process structuration is needed, and of when the student group needs teacher support and when the group members can support each other. Collective cognitive responsibility drives students to support each other, but teacher assistance is also required. Transferring from solely teacher-orchestrated learning to collective knowledge-creation practices might be more beneficial to LD students' sense of belonging, which could have a positive effect on their self-concept. It is evident that this investigation serves merely an analytical model for more profound analysis. In the next phase, we investigate other invention teams involved in this co-invention project. However, further studies in other schools and with different projects are required.

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Acknowledgments

This material is based upon work supported by the Academy of Finland grant 286837 (Co^4-Lab) and Strategic Research Council grant 312527 (Growing Mind). The opinions expressed here are those of the authors and do not represent the views of the funding agencies.

Knowledge building and the practical design principles in the Master Learning and Innovation of Aeres Applied University, the Netherlands.

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Abstract
Ten years ago we developed a Master of Education master program Learning and Innovation (M.Ed-M.LI) for teachers in vocational education (including Higher education and Applied Universities) and in business. The MEd program is based on the knowledge building pedagogic approach. The M.Ed-M.LI is a two years part-time program. Students have a bachelor or equivalent, preferable in teacher education and at least two years of working experience. The students are in the age range 24-58. The last five years the M.Ed-M.LI is rated as one of the TOP-master programs in the Netherlands. The rating is based on score of the national accreditation board (NVAO) and on the Dutch National students' evaluation data. We our self are convinced that the knowledge building approach is besides other factors the main cause for the recognition as a TOP-master program. At least it gives us a distinctive profile and identity in contrast to the other master programs and especially the other 8 M.Ed-M.LI programs in the country. The staff spent regular reflection and conversation time in their staff-meetings concerning the knowledge building in the sense how are we doing this, and what can be improved. The staff came to a point to write down the experiences. Although, the quality of the M.Ed-M.LI as very high and despite the staff reflections, it's still not clear what interventions and design features of the program stimulate knowledge building.
Five semi-structured interviews were conducted to identify design principles for stimulating knowledge building. Four design rules are similar between all curriculum themes (topics): *the student's own idea as starting point, students form collectives* around one (collective) issue, *collective insights are reflected in the theme product, connection with the own practice* is important. The differences show that teachers customize the pedagogical approach to stimulate knowledge building in their own teaching context and give input for the theoretical discourse on knowledge building.
Writing to learn by explicating the practical pedagogical design rules that teacher apply in their theme's and organizing the knowledge building. That is what we like to share with others and learn again from them.

Introduction
In the Netherlands many innovations are taking place top down by the management initiated by ministry of education, developments in society and bottom up by teachers themselves because they believe it can be different or better. This continuously working on improving education brings a need from the practice for school leaders (Verbiest, 2014) and teachers who can take the lead as researcher-innovators in these innovations. Our idea is that the process of innovation is supported by a knowledge creation process (I. Nonaka, 2006; Ikujirō Nonaka & Takeuchi, 1995). So, it is important to develop knowledge creation competencies and how could this be develop better than just do it yourself as a student. The knowledge building pedagogy (Bereiter, 2002) offers good opportunities to develop students' knowledge building competencies (De Jong, 2015). That is why the pedagogy in the M.Ed program is based on the principles of knowledge building (Marlene Scardamalia, 2002) and responsive learning approach (De Jong, 2015). In education, the knowledge building approach focuses on collective cognitive responsibility, involves students in idea improvement and engages students in a community to create new knowledge(Chan & Chan, 2011). Over the years, empirical research has demonstrated the positive effects of the 'knowledge-building' approach on literacy, depth of inquiry, collaboration, and knowledge-creation processes (Chan & Chan, 2011). However, for teacher in our program it is a continuously discourse to

[1] With thanks for the contributions of all the MEd Learning and Innovation Staff members, Hennie van Heijst, Niek van Benthum, Ard Sonneveld, Tom van Oefelt, Jantine van Beek, Joan van de Ende, Pieter Seuneke and Elsbeth Spelt.

find what design principles are effective to use. Therefore it is needed to explicate them also the ones that stys implicitly most of the time.

Study context

The two year part-time MEd-MLI is built around 5 fixed thematic curriculum topics (we call them themes: innovating in teams; learning; designing learning; communication and innovation; innovation ecology). Students study those themes by formulating their own questions, curiosities, statement etc. related to the a particular theme and their innovation project in their working context. The study and knowledge building activities in the context of a theme takes place during periods of about three months. As mentioned, during the two years of the part time master program students also work on an innovation in their work context and support this with practice oriented research that has to contribute to the innovation. Therefore during the two years students also study in the curriculum themes Research, Methods and Analysis. Students' innovation-activities result in a personal portfolio about the student's role as innovator and research results in a master thesis. Both products are part of the final assessment and master defense or M.Ed graduation.

Each topic in the program aims to bring about the knowledge creation process within that theme, leading to a final product; a theme product. This theme product can be seen as the conceptual artifact (Marlene Scardamalia & Bereiter, 2006) as the result of a knowledge creation process.

We expect that the intentional design of and the practice of the knowledge creation process depends on: the content of the theme (qualifications, sources, concepts); the place of the theme in the program (beginning, middle, end); and the personality of the theme core-teacher. So, we expect that the knowledge creation process does not always run the same way. It also depends on the style of the teacher(s) involved, the content of the theme and the process that students go through during the program. Although, students perceive the quality of the M.Ed-M.LI as very high, resulting in a TOP-ranking for five years in a row, it's still not clear what interventions and design features of the program stimulate knowledge building.

The first aim of the current study is therefore to get to the surface the design principles with regard to the intention to support the knowledge creation within each theme and to get a feeling of the impact of those principles. A second aim is to understand the similarities and differences in knowledge creation within the different themes in the M.Ed-M.LI. So, this brings us to the central question: *which principles, e.g. elements in the design of the course theme supports and stimulate students' knowledge creation process?*

A demarcation was made for the design rules. The study focuses on the design of the theme and the view is therefore broader than just the pedagogical actions of the teacher (s) in a particular theme. The assumption is that the pedagogical actions are guided by the design principles of a theme. And stimulating knowledge creation is not only stimulated by the pedagogical activities used (where the pedagogy concerns the choice of teaching methods and interaction with students), but also by the (pedagogical)design principles of the theme. The design forces the pedagogical practices.

By clarifying which principles stimulate the process of knowledge creation among students, we expect to gain more insight into strategies on how to stimulate knowledge building to contribute to the discourse on knowledge building and more specifically into ongoing pedagogical knowledge building 'teaching'-processes in a theme and the M.Ed-MLI program-wide, across-themes with respect to the students' knowledge creation.

Method

Over a period of three months during the 2016-2017 academic year, 5 theme core-teachers of the 'substantive' themes were interviewed. It concerns the curriculum themes: Innovating in teams; Learning; designing Learning; Communication and innovation; Innovation ecology. Core teachers have the main responsibility for the content and the pedagogical practice and teaching practice in the course. The average age is 44,8, Sd 10,2, range 36-62 years of age. Four of the five teacher have eight years of teaching experience in the M.Ed-M.LI and try to bring the knowledge creation pedagogy into practice from the start of the Master program in 2009. The other teacher had 2 years of experience in the M.Ed-M.LI. The aim of the interviews was to explicate the implicit and explicit design rules teachers use in order to support and stimulate students' knowledge creation.

The CIMO-logic method was used (Van den Berg, J., Hoeve A. & Zitter, 2012) to explicit which mechanisms underlie the cause-effect relationships. The interviews had an open character and were carried out by two other teachers from the master staff. As a start of the interview the teacher's theme curriculum guide, the knowledge building principles (Scardamlia, 2002) lay on the table. One question was asked: *"which elements in the design of the theme encourage students to create knowledge?"* During the interview-conversation utterances expressing design principles were written on the WiKi-wall (see fig. 1) in explicating the design principles.

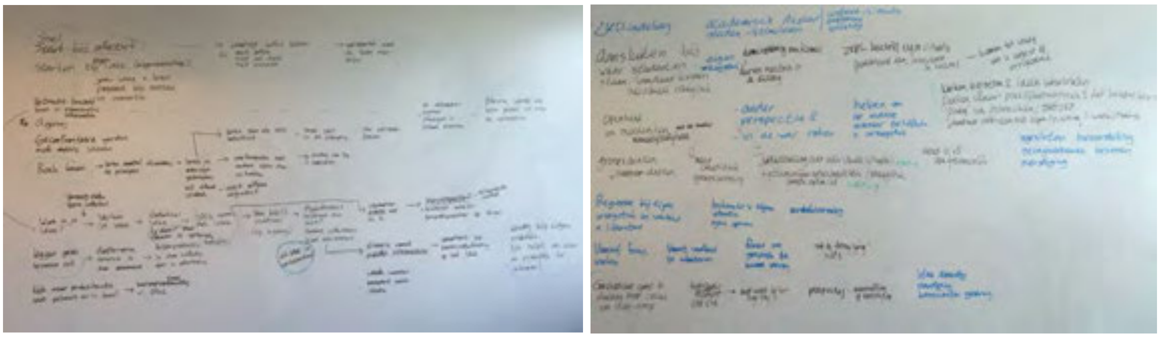

Figure 1: Utterances during the interview related to design principles were written on a WiKi-wall.

By directly writing it down on the wiki-wall, it was checked by the interviewed teacher if this was what he/she meant to say (direct member check). If so it was discussed what outcome was intended by it e.g. what in the students' knowledge creation process did he/she wanted to support with it. It turned out a kind of bycatch the conversation did not turn out a just a reproduction of what the teacher already knew, but they became aware of implicit design guidelines that the teacher had not realized yet. At the end of the interview, the interviewee was asked to arrange maximum 10 design principles in order of importance. Interviews were audiotaped with an informed consent of the interviewee. The pictures of the WiKi notes (see fig. 1) were analyzed on design principles and if needed the audiotapes were consulted. Results of this first cycle of analysis were submitted to the teacher with the request to add additions if the missed something. Almost no adding's were made.
After analyzing the interview data on similarities and differences between themes, as a member check, the design principles for each theme were shared and discussed in the master's staff-meeting with all the involved theme core-teachers. It was also made explicit what the similarities are: which design principle is active in each theme? And what are the differences between the themes in this respect.

Results & Conclusions

The following four design rules seem to be active in all the themes (similarities between themes):

1. *Idea development* is the basis for education and the knowledge development of the themes. The starting point for each theme is *the student's own idea* of the issues that evoke the theme: starting point is the students' experiences in their own practice, and the problems and issues that arise there.
2. From their own ideas and the start of idea development, *the students form collectives* around one (collective) issue. Knowledge development on the basis of this issue, and linked to the own and collective idea improvement, leads to collective insights.
3. These *collective insights are reflected in the theme product*. Examples of collective insights, as they are included as a theme product, are: a breakthrough perspective for the process of innovation; a vision on learning and a strategy of communicating in an innovation process.
4. In the process of idea development, knowledge development and coming to collectives, *the connection with the own practice* is important. Practical knowledge, experiential knowledge and scientific knowledge are brought in by students in the dialogue with each other, explored, doubted and build-on. This process is also called *inquiry learning*.

The differences between the themes with regard to the stimulating students' knowledge creation process are described from five perspectives: 1) the formation of the collectives; 2) cycles of inquiry learning; 3) the collective artefact and the collective knowing; 4) the 'place' of the process of knowledge creation; and 5) interrelatedness of themes.

Formation of collectives

In the theme Innovating in teams, students work during the first half of the theme period on the basis of an individual issue. The students first explore their own context from a theoretical perspective before they (the second half of the theme period) form collectives and focus on a collective issue in order to come to promising groundbreaking ideas. In contrast, within other themes, the collectives are not formed directly at the first meeting.
The idea behind this difference is that students in the first theme also have to 'get used to' the pedagogy of knowledge building and that they also go through a social process with each other. During the meetings, group discussions (dialogues) therefore take place in small groups with a view to knowledge development on a small scale and (in particular) to get to know each other. In addition, the experience is that students by deepening themselves in the theory get some distance from their own practice. That makes that they can look at their own

environment and the practices of others in a more analytical way. In this theme, obtaining the knowledge building competence is stimulated through a more individual process than through a collective process approach.

Cycles of inquiry learning
Both, theme Innovation in teams and theme Communicating within innovations, work with short cycles of research (progressive inquiry) during the theme, while in other themes one works with only one cycle.

A collective conceptual artifact and collective knowing
Theme Learning distinguished itself form the others by a collective conceptual artifact (manifest) as a guideline for the knowledge building process. Theme Communicating and the theme Environment distinguish themselves from each other in using central questions to strengthen the collective knowledge building process.

The 'place' of the knowledge creation process
Theme Design for learning, distinguished itself by the fact that knowledge creation takes place in the workplace, in design teams that are composed of colleagues. Partly because of this, little use is made of the students community of knowledge building in the MEd-MLI program. Knowledge Forum is not used in this theme, in contrast to the other themes. Peer-2-Peer is used environment for generating students' feedback to each other and of colleagues.
Knowledge creation is embedded in the assessment of the theme Designing learning. Two criteria are assessed: 1) how others have experienced in which way the student has created knowledge; 2) in the work with colleagues. For example: The student brings connections between sources in the dialogue with others, builds on the insights of others and can use new common insights with others to substantiate the design. So the knowledge building is more situated in the face-to-face meetings and conversations on the workplace.

Interrelatedness of themes
Theme Communication differs from the other themes by choosing to use only one practical situation per collective group. In addition, there is an interweaving with the theme Research and Innovation on the content and implementation of the theme and in the theme product.
The theme Learning in which students' develop their vison on learning in relation the learning of the participants in the innovation of their workplace. The developed vison on learning is actually the starting point on which the students build-on in the theme Design for learning.

Overall conclusion
Although there are common principles that can be identified used in each theme, there are also considerable differences. The differences are based on the teacher's preferences and style, the familiarity with the Knowledge Forum environment and the knowledge building theory. The latter despite the frequently attention and dialogues about the knowledge building in the MEd-MLI staff team.
In relation to the knowledge building principles as expressed by Scardamalia (2002) and(Scardamalia & Bereiter, 2014) we see communality with the four design principles used by the teachers. Design principle one relates to *Idea improvement*, the epistemic starting point that there is not such a thing as a final truth, perfect theory, technology or living together is central in the teachers' pedagogical thinking and design principles used. Design principles two and three relate to *Community knowledge advancement.* The view that knowledge is not a proposition of a person, but of a culture and community and it contributes to the wisdom of the community and its members. Although, it still is difficult in the educational culture and sometimes not even possible because of accreditation regulation to prove individual assessed level of competence and knowledge to leave behind an individual approach of learning. And the forth design principle relates to *Knowledge building discourse* as a creative role instead of a critical role and a collaborative process; and *Constructive use of authoritative information*. This means all kinds of information, first-hand experience, secondary sources, etc, that has value in the knowledge building process in a constructive trans-literacy practicing. Design principles three and four also cover the knowledge building principle *Understanding as collaborative explanation building*: producing principled practical knowledge by connecting concrete experiences to more generalizable knowledge. The theme products, e.g. conceptual artefacts result from a knowledge building process as an innovation process, based on 'principle practical knowledge' and theoretical concepts in a coherent explanation for practical use (know-how combined with know-why).
Conclusively, results show similarities and differences in design for stimulating knowledge building. The similarities show that there is a generic base for stimulating knowledge building. The differences show that the pedagogical approach are customized by the teachers to stimulate knowledge building in their own teaching context and give input for the theoretical discourse on knowledge building.

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Acknowledgments

Thanks to Aeres Wageningen University of Applied Sciences and especially the Faculty of Teacher education to make this research possible by supporting teacher capacity and financially.

Promoting Students' Participation in Classroom Discussions through Knowledge Building Circle

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Abstract: This article reports a design experiment conducted process for a novice teacher with Knowledge Building (KB) theory to orgnize and improve the Knowledge Building Circle(KBC) discourse, with the teacher's goal of having his Grade 4 students assume increasing levels of collective responsibility for advancing their knowledge of animals. The process was divided into two stages to make a comparative study for showing the differences between the common classroom KB Discourse in phase 1 and KBC Discourse in phase 2. After all the Classroom Discourses were transcribed into texts, the researchers rated the knowledge depth of students' questions with depth of knowledge scale and evaluated the answers of students' questions by rating the depth of explanation. Data analysis results show that the KBC strategy not only effectively improves students' classroom participation, but also develop the students' ability to express their ideas and increase students' knowledge advances. At the same time, the paper discussed the organizational rules and implementation principles of the KBC strategy based on teaching iterative process.

Introduction

The project group has been carrying out the teaching reform of Knowledge Building theory since 2012, in this period the researcher finded that it always was difficult to improve the quantity and quality of students' participation in Knowledge Building Discourse in classroom. Although many factors may affect students' participation in discourse, the traditional seating arrangement and the form of discourse in classroom may be the important influence factors. In the traditional classroom the sutdents always sitted in rows and rows, the teacher usually stood their opposite, under these circumstances the organization of classroom activity could not encourage every student to take part in the discourse. In order to improve the effect of Knowledge Buliding Discourse, A comparative experimental research was carried out in class 1 Grade 4 (18 boys and 13 girls) in Baiyunyuan Elementary School which has been reforming the Science Curriculum for three years with the KB theory. The science curriculum spanned 12 weeks, 3 hours per week, 40 minutes per class and the teaching topic was *Animals* during the project implementation. 6 regular KB Discourses in the traditional classroom were held in March and April at phase 1(from the 1^{th} week to the 6^{th} week), and another 6 classroom discourses based on KBC strategies were conducted in May and June at phase 2 (from the 7^{th} week to the 12^{th} week) according to the lesson and school schedule. The term KBC refers to the seating configuration of students as they engage in KB Discourse (Chiarotto, 2011). Usually, the teachers and students sit together in a circle. Having students become active agents in knowledge construction is an important theme in the learning sciences literature (Bell & Linn, 2000; Engle & Conant,2002; Scardamalia & Bereiter, 1994) and it is very effective for students to build collaborative knowledge. Active participation in KBD is an important characteristic of becoming an active agent. In this project the KBD in classroom was conducted mainly through students' questions and answers, so the quality of questions and answers becomed the important indicator of KBD assment.

Method

Participants.

Participants included a Science teacher and 31 students from class 1 Grade 4 in Baiyunyuan Elementary School which has been reforming the Science Curriculum for three years with the Knowledge Building theory. There were 18 boys and 13 girls in this class. However, one boy was absent more than one-third of the class time because of poor health and a girl transferred to the other school in midway, so the actual number of participants is 29. In order to further promote the research of this project, two assistant teachers (master graduate student A and master graduate student B) majoring in KB theory from Nanjing Normal University participated in the research for collecting and recording data.

Procedure

The researcher designed and adjusted the content of the course according to the teaching plan, at same time choosed appropriate criteria to measure the quality of questions and answers in KB Discourse. The students' classroom discourses were always transcribed immediately into content texts according to the Audio and Video recordings in classroom after class, and they were labeled as questions texts, answer texts of questions and others speech texts, the amount of statistics for all of these contents is shown in Table 3. In order to analyze the classroom discourses texts, DOK (Depth of Knowledge) model (Webb, 2002,2017) was adopted for rating question texts (see Figure 2) and Rating Scheme for Depth of Explanation (Lee,2006) was used for evaluating the answer texts of questions (see Table 1).

Figure 2. DOK Model.

Table 1: Rating Scheme for Depth of Explanation.

Rating	Description
1	Repeat or simply restate a fact or a statement that has been made
2	Give factual information and general description; responses are usually centered on facts and topics; Fcut and paste; is used rather than making own interpretations
3	Give responses and make inferences supported with some relevant information
4	Make assertions supported with explanation, evidence and relevant examples
5	Refocus discussion or highlight key conceptual issues for further inquiry; bring out other aspects of issues for discussion
6	Recognize high points in discourse; metacognitive, show personal reflection
7	Synthesize different points of views and make a 'rise-above' summary

Four levels of depth of knowledge are used for students' questions analysis. Level 1 expresses students to receive or recite facts or to use simple skills or abilities; Level 2 includes the engagement of some mental processing beyond recalling or reproducing a response; Level 3 showes understanding of the ideas in the text; Level 4 indicates students can develop hypotheses and perform complex analyses of the connections among texts.

At Phase 1, students sitted in rows and rows in classroom and learning through the Knowledge Building Discourse. At Phase 2, the teacher used the Knowledge Building Circle in classroom teaching and the method of Based on Design Research was adopted for the lesson design. The researchers and teacher usually had a face-to-face rethinking for the specific teaching process after the class and adjusted the strategy of Knowledge Building Circle before next discussion according to the analysis of previous class discourse. The iterative process of the design scheme is shown as the following Figure 1.

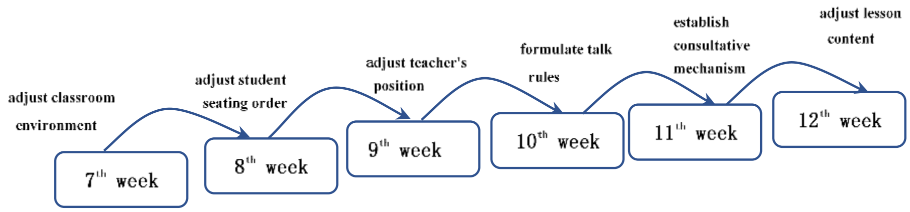


Figure 1. Strategy of Adjustment in Iterative Process.

Coding

The weight scoring coding method was involved in this study. The paper only lists the coding process of Knowledge Depth of answer texts about Ant and Snail shown in Table 2 and the coding processes of other topics are similar to them. Ant is the first topic in the Knowledge Building Discourse (KBD) classroom happening in the first teaching week at phase 1 and Snail is another topic in the Knowledge Building Circle Discourse (KBCD) classroom happening in the seventh teaching week at phase 2. All the content texts of questions about Ant and Snail were listed in the table2.

Table 2: Coding of Discourses Texts

Phase 1											
Topic	Sn	Wn	KBC	Qn	Question Content	T (40%)	A (30%)	B (30%)	Calculate	Evaluate Rating	Avg
Ant	15	01	0	01	How many legs does the ant have?	1	1	1	1	1	1.67
	15	01	0	02	How many colors do the ant has?	1	1	1	1	1	
	15	01	0	03	Do ant has eyes?	1	1	1	1	1	
	15	01	0	04	Is there any white ant?	1	2	2	1.6	2	
	15	01	0	05	Is there any ant that can fly?	1	1	1	1	1	
	12	01	0	06	Is the ant a pest?	2	2	3	2.3	2	
	12	01	0	07	Can ant fight?	1	1	2	1.3	1	
	12	01	0	08	How does ant find their companions?	1	2	2	1.9	2	
	12	01	0	09	How does the ant breed?	2	3	2	2.3	2	
	09	01	0	10	How did the ant find home?	2	2	3	2.3	2	
	09	01	0	11	Will ant go the wrong way?	3	2	2	2.4	2	
	05	01	0	12	Can the ant make a mistake in helping the other ant?	2	3	2	2.9	3	
Phase 2											
Snail	01	07	1	01	Do snail have legs?	1	1	1	1	1	2.67
	01	07	1	02	What is the shell of a snail used to do?	1	1	1	1	1	
	07	07	1	03	Can the shell of a snail be changed?	2	2	2	2	2	
	07	07	1	04	How can the snail's shell be replaced?	2	2	3	2.3	2	
	15	07	1	05	When will the snail's shell be changed?	4	3	3	3.4	3	
	15	07	1	06	Will snail die after it's shell is replaced?	3	3	3	3	3	
	12	07	1	07	How does the snail use its tentacles to explore way ?	4	4	4	4	4	
	12	07	1	08	Does a circle of thread on a snail's shell represent a year?	4	3	4	3.7	4	
	15	07	1	09	Do snail's antennae work like ants' antennae?	4	4	4	4	4	

In the encoding table 2, Sn represents the student number, Wn represents the week number (1-12 weeks), and KBC indicates whether the Knowledge Building Circle is used (0 is unused, 1 is used), and Qn represents the question number. The Rating of question is evaluated by professional teacher (T), the assistant teacher A and the assistant teacher B with DOK model. The final evaluation grade is composed of teacher's score (40%), assistant A’s score (30%) and assistant B’s score (30%).

Result

The participation of students increased surprisingly. By counting the frequency of student participation in discussion at two stages, the average speaking frequency of students is significantly improved, as shown in Figure 3.

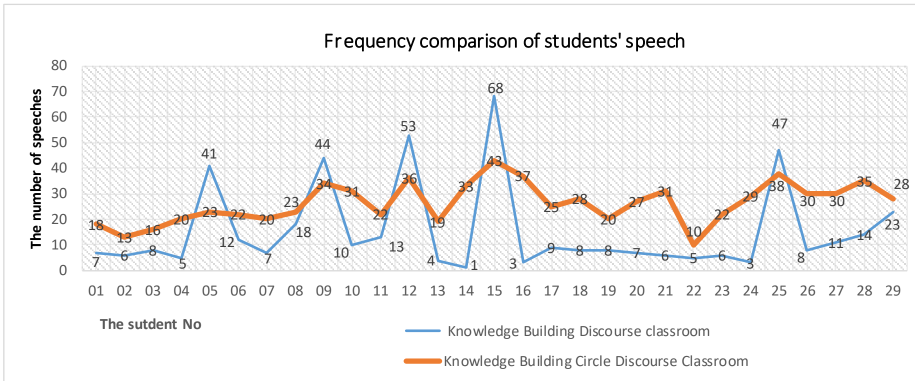


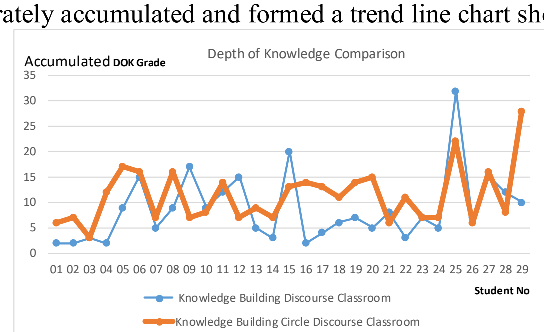
Figure3 Frequency of Student’s Speech

The quality of questions and answers to questions were all improved obviously. There are 110 questions and 219 answers in Knowledge Building Classroom Discourse at phase 1, the depth of knowledge grade of questions and explanation rating of answers are lower than phase 2. The percentage of DOK grade 4 and Explanation Rating 7 are only 9.09% and 11.89%, but the percentage of DOK grade 4 and Explanation Rating rose to17.82% and 22.77% at phase 2(see Table 3).

Table3: Knowledge Depth of Question and Explanation Depth of Answer.

Counting / Phase	Number of Questions		Number of Answers		Number of Conversation
	DOK Grade 4	Questions	Explanation Rating 7	Answers	neither questions nor answers to the questions
Knowledge Building Classroom Discourse	10	110	12	219	126
Knowledge Building Circle Discourse	18	101	23	358	304

Each student’s DOK scores of the questions and the explanation rating scores of the answers were separately accumulated and formed a trend line chart shown as Figure 4 and Figure 5.



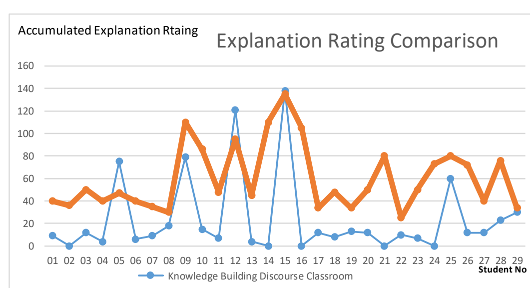


Figure 4 DOK Scores of Questions

Figure 5 Explanation Rating of Answers

It can be clearly seen that the use of Knowledge Building Circle Discourse in classroom can effectively improve the knowledge depth of question and the explanation rating of the answers. At the same time, a paired sample test was performed to examine whether a significant difference exists in the DOK of question between phase 1 and phase2; another paired sample test was performed in explanation rating grade of the answers. The results were shown in Table 4 and table 5.

Table 4: Knowledge Depth of Question Paired Samples Test.

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	1-6 weeks（KBD） 7-12weeks（KBCD）	-2.862	6.099	1.133	-5.182	-.542	-2.527	28	.017

Table 5: Explanation Rating Grade of Answers Paired Samples Test.

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	1-6 weeks（KBD） 7-12 weeks（KBCD）	-25.483	39.309	7.299	-40.435	-10.530	-3.491	28	.002

In this study, the analyses of DOK of questions and explanation rating grade of the answers, respectively, $p< .05$ fully indicated that there are significant differences between KBD classroom and KBCD classroom.

Expressive ability and interpersonal skills have improved significantly. The content texts of classroom discourse were coded from the dimensions of language expression, emotional state and mutual respect based on the Evaluation Scale of Oral Communicative Competence (Center for Basic Education Curriculum Development, 2004) for the junior grade of Primary School Students, the encoded data statistics are shown as in Table 6.

Table 6: Rating Scheme for Students' Discourse and Behavior in Classroom.

Dimension	Grade	Content Description	Number	
			KBD	KBCD
Language Expression	1	The expression is poor, difficult to express ideas, long pause, need teacher guidance.	52	25
	2	The expression is not very smooth, short puase, the main idea is vague.	83	65
	3	The expression is basically complete, and occasionally pause. The main idea is a little blurred.	232	421
	4	The expression is clear and fluent. The main idea is clear.	88	252
	Total		**455**	**763**
Emotional State	1	Nervous, dare not speak	83	34
	2	The voice is short of nature and the tone is dull	110	120
	3	The voice is natural and generous, and has certain appeal, but the effect is general.	150	300
	4	The voice is natural and generous, which can appeal to	112	309

		the audience and be infectious.		
	Total		**455**	**763**
Mutual Respect	1	Offensive words, such as satire, sarcasm, short notice, difficult questions in public, etc.	14	2
	2	Critical words, such as I objected, he said is wrong.	240	201
	3	Advise words, such as if I think so, I think he should/he can.	70	411
	4	Encouraging words: such as he is right but needs to work hard. He has some reasons, but... On the other hand, there are still shortcomings, etc.	21	147
	Total		**345**	**662**

The statistics data in dimensions of language expression and emotional attitude include all students' speeches, but the statistics data in dimensions of mutual respect exclude the number of questions from all students' speech.

The statistical results indicate that the student's promotion is very obvious. There is no significant difference in the second grade of language expression dimension between KBD and KBDC. It is due to the fact that the students didn't or passively take part in the KBD classroom but actively participate in the KBDC classroom.

Discussion

After many iterations of Knowledge Building Circle teaching strategy in classroom teaching at phase 2, the author finds that the following rules should be established for improving teaching effectiveness and students' earning quality.

Formulating rules of Knowledge Building Circle

1. *Adjusting the students' sitting order and their adjacent relationships*. Teacher should make some arrangements according to the students' activity degree, learning ability and prior knowledge level, try his or her best to minimize the obvious differences between neighboring students. At the same time, she or he should adjust flexibly according to the facts of the content of classroom and the content of the course.

2. *Determining the position of the teacher.* Teacher should sit in the middle of students who have low class enthusiasm and the poor learning level and ability. The teacher is an equal member and should be a coordinator and organizer of the topic, not the leader and the leader of the topic.

3. *Making the rules of discourse in the Knowledge Building Circle.* First, fairness. Every student has an equal opportunity to give his/her ideas, it is necessary to take turns to speak, not to be a silent person and the spectator; Second, respect. The responder must wait for the speaker to finish expressing his/her ideas completely to answer or ask a question. They should not ridicule and belittle the questions and the answers students gaved Third, participation. It is the responsibility and obligation of each circle member (including the teacher) to actively ask questions and answer questions, then make their best efforts to contribute to the community knowledge; Fourth, psychologically safe. It is necessary for students to realize that they can express their real ideas without any pressure and worry; at the same time, they do not need to feel overly attached to a specific theory, as theories and ideas can be adopted, criticized, and developed by peers within their group and by other groups (Zhang, Scardamalia, Reeve & Messina, 2009).

4. *Establishing a democratic consultative mechanism.* The principles of democracy should be adopted to coordinate different ideas and controversial opinions, it is necessary to discuss, argue and even debate for the diverse ideas to reach a consensus, but to avoid "tyranny of the majority". On the other hand, the teacher should coordinate and dredge the dissenters who are extremely special and unable to reach any agreement.

5. *Formatting academic beliefs.* All members including teachers in the discourse classroom should believe that the whole community knowledge can be improved through presentation real ideas and they can contribute to the theory of discipline by sloving the authentic problems in context.

The Number of Student in a Class

Although the Knowledge Building Circle strategy in classroom discourse can effectively promote students' learning performance, the students in class are not too much. Heidi believes that the number of student in Knowledge Building Circle is between 16 and 25 (Siwak, 2015). If there are more than 25 students, there will be conversation confusion, and it cannot be ensured that all students fully participate in the process of conversation, so the teaching effect of the knowledge construction circle will be discounted.

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Innovative Format Proposals

Knowledge Building Collaboratory: An Open Platform to Support Collaboration on Innovative Initiatives for Knowledge Building Research and Practice.

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Statement of the Issue

Knowledge Building (KB) fosters a culture of innovation in which students work as a community engaged in sustained idea advancement and knowledge creation (Scardamalia 2002). In a KB community, students assume collective responsibility, work in “design mode” seeing any idea as worth of consideration and passive of improvement, and focus on advancing their collective enterprise of innovation rather than the personal knowledge of each individual. In this same spirit, the KB Collaboratory is an open digital platform that aims to support innovation on research and practice of KB itself. The challenge is to go beyond mere sharing of information, and provide support for sustainable innovation. For that, the KB Collaboratory will work in symbiosis with Knowledge Forum (KF), providing and open environment where any KB researcher or practitioner can discover and engage with ideas and initiatives that were started on a KF community, or that can be advanced on KF views automatically generated from the KB Collaboratory itself.

Goals

Our major goal is to get the KB community engaged in a functional pilot of the KB Collaboratory to explore its design and features. Participants will be able to create KB Collaboratory accounts, browse and read more than four hundred prepopulated entries, create their own, and contribute to the advancement of those ideas on their respective KF views. We expect that, after exploring the pilot, the community will them be able to engage in the co-design and advancement of the KB Collaboratory platform itself, offering feedback and ideas for improving its structure and interface.

Description of Audience Engagement

This is a **participatory workshop** that aims to engage participants in the co-design and advancement of KB Collaboratory. After a short walkthrough (5 minutes), participants will freely explore the prototype on their own computers or mobile devices (25 minutes). Participants will then be divided in small groups for discussion on possible improvements (30 minutes). Finally, small groups will report their ideas for a whole group discussion (30 minutes).

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Knowledge Building Analytics: from Analysis to Actionable Insights

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Gaoxia Zhu (co-chair), Leanne Ma, Ahmad Khanlari, Stacy Costa, University of Toronto
Alwyn Vwen Yen Lee, Seng Chee Tan, National Institute of Education
Xueqi Feng, University of Hong Kong
Wanli Xing, Bo Pei, Texas Tech University

Statement of the Problems

Knowledge Building (KB) has a long history of data analytics that dates back to the 1990s. Many analytic tools have been developed by the community (see Zhu & Kim, 2017 for a review), in order to help monitor KB activities, analyze social networks, and evaluate idea development (e.g., Oshima, Oshima, & Matsuzawa, 2012; Yang, van Aalst, Chan, & Tian, 2016; Zhang, et al., 2015). As new analytics efforts continue to emerge, there is a critical need to assess the status quo of KB analytics and identify promising analytics designs we should invest in.

In KB, analytics are developed with quite unique goals. Instead of serving academic accountability purposes (e.g., Purdue Signals), KB analytics are based on principles (Scardamalia, 2002) and developed to empower learners' epistemic agency, design-mode thinking, and choice-making (Chen & Zhang 2016). More work is needed to strengthen these unique design goals. Achieving it would require closer alignment between KB principles, discourse practices, data capturing, analytics tool design, and analytics implementation in classrooms (Wise & Vytasek 2017). Further, we also need to engage key stakeholders, especially teachers, in the design of KB analytics given an increasing emphasis on human factors in learning analytics systems.

Major Goals of the Interactive Symposium

This year's Summer Institute provides a great opportunity for the community to advance KB analytics. Through this symposium, in coordinate with the "Analyse-Reflect-with-Technology" symposium, we hope to achieve the following goals:

1. Enhance our awareness of analytics development in this community
2. Start to establish a shared set of principles to guide KB analytics development
3. Self-organize ourselves to work on both "grand challenges" and "low-hanging fruits."

Overview of the Symposium

The symposium will begin with a series of brief presentations featuring emerging work in our community.

Short Presentations

Introduction: History and Challenges (B. Chen & G. Zhu): The symposium co-chairs would present a brief review of the historical development of KB analytics, followed by a discussion of major design challenges. They will also provide an overview of the symposium's participation structure to scaffold productive dialogues.

Innovation Metrics in Knowledge Building Communities (L. Ma): Collaborative Innovation Networks (COINs) and Knowledge Building communities represent powerful models conducive to the emergence of collectively intelligent behaviours in both organizational and educational contexts. This presentation highlights the theoretical intersections between these two models of innovation in order to explore technological designs for visualizing collective intelligence in Knowledge Forum. More specifically, the six indicators of COINs—rapid response, balanced contribution, central leaders, rotating leadership, honest sentiment, and innovative language—are refined and adapted within the context of the 12 Knowledge Building Principles. Next-generation designs for Knowledge Forum analytics using social network analysis, lexical analysis, sentiment analysis, and statistical analysis are proposed.

Idea Diversity Index (A. Khanlari). In KB, the diversity of ideas plays an important role in the ecosystem of knowledge, and the ability to advance knowledge highly depends on recognizing and respecting others' ideas. This study aims to develop an analytic tool to provide an index for idea diversity in Knowledge Building communities. It is hypothesized that in a genuine KB community, the diversity index has a bell-shaped curve. At the beginning, the diversity is low as there are few ideas; it then increases as students engage more in knowledge building discourse; and finally it decreases as students gradually rise-above their ideas. However, if the community continues to generate more new ideas without synthesizing them, the diversity index will not decrease, and the community may not be considered a genuine KB community. As there is no end for idea improvement, this process may repeat, which may result in several bell-shaped curves. We employ Natural Language Processing techniques and semantic analysis methods like the cosine similarity (Diversity = 1- cosine similarity) to develop this tool. There are three steps to calculate idea diversity in a Knowledge Building community: (1) nouns and names in students' notes are extracted to create a matrix of word frequencies using Python's Natural Language Processing Tool Kit (NLTK) and Part of Speech (PoS) technique, as it is assumed only nouns and names represent concepts (Kopainsky, Pirnay-Dummer, & Alessi, 2012); (2) the similarity index between individuals' notes is computed over time, using the Cosine Similarity metric (Leydesdorff, 2005); and (3) the similarity index will be converted to the diversity index using the aforementioned formula to reveal how the idea diversity changes over time and whether students synthesize their ideas. This tool can be used to examine KB communities from two knowledge building principles' perspective: idea diversity and rise-above.

Facilitating Identification of Promising Ideas Through Analytics and Machine Learning (S. C. Tan & A. Lee): Recognising promising ideas is an important component of expertise and creativity (Bereiter & Scardamalia, 1993) and has been established as an approach to supporting KB processes. To identify and analyse promising ideas, we developed a methodology called Idea Identification and Analysis (I2A), which employed network analysis, temporal analytics, and machine learning techniques to define attributes of promising ideas, recognize idea types and determine the impact of such ideas within online KB discourse. Using a defined set of attributes for idea promisingness and the betweenness centrality (BC) network measure, a classification system was developed to determine idea types in discourse based on the recognition of BC trend patterns. Temporal analysis was further conducted with text mining, visualisation, and clustering techniques to validate the findings. Qualitative analysis of the contents of notes could be followed up to verify the promisingness of the ideas. This research has implications for students and practitioners and contributes to KB discourse analysis by developing a methodology that will guide the analysis of ideas in knowledge building discourse.

Exploring the Interaction Between Emotions and Idea Improvement in Knowledge Building Circles (G. Zhu, W. Xing, S. Costa, & B. Pei): KB discourse takes place in both online and physical spaces such as the Knowledge Building Circles (a.k.a. "KB Circles"). In a KB Circle, a teacher and students sit in a circle that everyone can equally participate in the KB discourse through which they collectively develop community norms and build ideas (Reeve, Messina, & Scardamalia, 2008). Therefore, understanding the dynamics of a KB Circle is critical to understanding KB discourse. Speech emotion recognition technique opens new possibilities for studying KB Circles as it can automatically detect different sets of emotions with speech-related features such as excitation source, vocal tract system, and prosodic features, speech emotion recognition technique (Koolagudi & Rao, 2012). Using this technique, we explored ways to detect students' emotions expressed in the recorded KB Circles discourse contributed by 22 Grade 2 students on mathematics and investigated how students' emotions interact with their idea improvement moves. Results suggested that confidence, neutral, and challenge emotions occurred most frequently in KB Circles while curiosity and surprise occurred much less. Emotions in a KB Circle could well predict students' simple claim, appraisal, or paraphrase and explanations, but not the other types of idea improvement such as explanation-seeking questions, new ideas, and regulation; and the students who spoke more in a neutral manner tended to elaborate reasons, relationships or mechanisms more.

Identifying Idea Friends (X. Feng): One way to design a Knowledge Building community is to engage students in working in small groups on different but relevant topics. While much work happens within small groups, they could also benefit from inter-group interactions and community-level knowledge creation. To this end, we developed a pedagogical design embedded with a tool called Idea Friends Map to promote small groups to interact with one another and to advance community knowledge. Small groups can use the Idea Friends Map to compare the similarities and differences of ideas between their own groups and other groups; to explore the latent relationship among different topics; identify promising ideas; and to recognize knowledge gaps between what they have generated and their goals. This presentation will introduce pedagogical designs of using this tool in Grade 5 science classes in mainland China.

Audience Engagement

Following the short presentations, the audience will be engaged in a Q&A session, when they can ask presentation-specific and general questions.

While the Q&A session is ongoing, the co-chairs will work with all symposium participants to generate themes based the presentations and conversations. The audience will then be grouped around identified themes to work in small groups. Post-it notes and pads will be provided to each group for note-taking and paper prototyping. Each group will report back to the group and post a "rise-above" note to the conference's KF database.

Proposed Length of Session

90-120 minutes in total: 60 minutes for presentations and brief Q&A; 30-60 minutes of group work.

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Collaborative Annotations in Knowledge Forum: How to transform Knowledge & "Static" Learning with Students.

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Statement of the Issue:

In line with the World Economic Forum (2016) focus on collaborative work on complex problem solving at the elementary level, collaborative Knowledge Building (Scardamalia 2002) supports building ideas in an online space accessible to all participants. Scientific corpus and ideas are scattered across Knowledge Building (KB) communities, groups and even outside of knowledge forum databases. The information is fragmented and can assist users who are researching the same knowledge and information. Currently there seems to be a barrier between information within and out of Knowledge Forum. This is a key challenge that drives students, and teachers to want to not use Knowledge Forum. Beyond sharing, constructive uses of authoritative sources are essential to drive Knowledge Building (KB)(Scardamalia 2002). Students must take collective responsibility for advancing community knowledge, using resource material to extend their work beyond the ideas in the local community. By embedding discussion directly in texts, collaboratively a new discussion can emerge from authors, and community members. Open Collaborative annotations can be a unifying technology, to enrich engagement within a community, with a "static text" and where students can engage with a global community in which experts, or other students can join in to end the myths in misconceptions. Moreover, students can enrich context and be able to investigate, what might have been originally an agreed upon idea.

Major Goals:

One major goal is to introduce the Knowledge building community to web-based annotation, and to explore the specialized and untapped knowledge and misunderstandings and misconceptions that can inform students future idea development. As Greeno et al. (1996) note, "knowledge is distributed among people and their environment, including objects, artifacts, tools, books and the communities they are a part of" (p.20). Transliteracy, (Liu 2012), conveys the ability to negotiate the varied and fragmented informational world of the Internet, extending traditional conceptions of literacy and enabling students to work more consistently and effectively at the cutting edge of their understanding. By utilizing Collaborative annotation, students can increase their transliteracy. To maximize learning outcomes through productive use of resource material scaffolds will be designed to help students bring scientific texts into their community space to work collaboratively to understand difficult concepts, address structural weaknesses in arguments, summarize ideas introduced over time, identify "cutting-edge" ideas, tackle big questions, and more generally reshape & transfer ideas. Annotation software will additionally allow them to embed discussions directly in texts to facilitate productive analysis of online resources. The goal we transform to engage everyone in a Knowledge society and make those who were originally passive into a more active role.

Clear Description of Audience Engagement:

One thirty-minute presentations will demonstrate how collaborative annotation can occur in knowledge building communities. With a preview of the technology as well as a demonstrate of possibilities of how to use Collaborative Annotation within a Knowledge Building Community. As well, this presentation, will also be a call out for interested teachers and researchers to join in on this research endeavour over the next year.

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A Case Study in 21st Century Teaching & Learning: Getting it right or getting it started?

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1. Issue/Problem

As someone who has worked with knowledge-building technologies and pedagogies for nearly 20 years at Grades from three to Postsecondary in a variety and linguistic and cultural contexts, one of the greatest challenges I have faced is the tension between teaching at the edge of what I felt might be possible and the edges of what the learners and the system were ready to accept.
The perceived pressure to "get it right" stunted my willingness take risks and learn by "getting it wrong." This, in turn, stunted the possibilities of what my students could learn. In 2016, this tension coalesced in what turned out to be a three-year iterative development of an MEd course, An Introduction to 21st Century Teaching and Learning, which sought to integrate knowledge building principles, technologies, and pedagogies at the graduate level.

2. Major Goals

Using the 21st Century Teaching and Learning course as a case study, the goals of this session are threefold:

1. To introduce the challenges underlying the development of a knowledge-building course;
2. To summarize the initial design decisions and subsequent three-year evolution of the course;
3. To facilitate discussion and sharing among other educators of the design decisions, challenges, and possible solutions that they have faced in their respective contexts. If possible, an additional outcome might be the collaborative development and implementation of a new knowledge-building course.

3. Overview of Presentation and Format

This session will consist of three sections:

1. An overview of the 2016-2018 Introduction to 21st Century Teaching and Learning courses illustrated with examples drawn from the three Knowledge Forum databases at their hearts.
2. Small/large group discussion of the salient design decisions, challenges, and alternative solutions as identified by workshop participants.
3. Individual notes and a curated summary of the session in a workshop view in the KBSI 2018 database.

Time: 60 minutes; 20 minutes for presentation; 40 for discussion.

Analyse-Reflect-with-Technology: KB & LA in Curriculum, Pedagogy and Assessment of 21st Century Competencies

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Statement of the Problems

Knowledge Forum, integrated with Learning Analytics (LA), offers enormous potential for the different kinds of computational support for tracking and visualising patterns of idea growth and engagement both to teachers and learners. One of the challenges in the development of technologies, in this case, KF and LA, is in translating these technological potentials of KF and LA to impact practice is that researchers and practitioners have different goals in term of the LA utility and design. Researchers tend to focus on the advancement of learning principles through LA, while practitioners simply needed the LA to inform their work in different contexts. In recent years, there emerged much research effort on LA to ensure the syntheses are framed to meet practitioners' needs. Traditional knowledge broking concerning LA between researchers and practitioners need to be revisited and extended to align the needs of both of them better.

This session not only brings together a range of LA tools and techniques that have been integrated into knowledge building (KB) classrooms to inform practitioners on a regular basis. We invite Researcher-Teacher teams to present at this Analyse-Reflect-with-Technology (ART) session to provide a multi-perspective analysis of KB classrooms in relation to curriculum design, pedagogy decisions and transformative assessment so as to build a stronger connection between research and practice. We would like to focus on the use of LA in supporting the analyses and reflection but we also welcome the use of manual coding or analysis for triangulation of results. Some key questions the teams will address include: How can Learning Analytics impact teachers' understanding of their students' soft skills and process skills? What kind of 'conclusive' measurement can teachers and school leaders make as they navigate these complex visualisation of students' 21st century competencies? In this session, we hope to explore various analysis of knowledge building discourse aligned to the various 21st century competencies standards and benchmark adopted in different context and draw a stronger connection of between research and practice in the area of LA. We also want to note that the three areas of curriculum, pedagogy and assessment as seen in an actual KB classroom are rather integral and not distinct in the way we use them to frame this session.

Finally, we hope the presentation and discussion in the session can contribute towards the design of professional development model for teachers to develop teachers' literacies around analytics within the KB context. Similar to how students develop competencies around number to pictorial to abstract representation, teachers require scaffold to understand these new way of visualising as a set of new measures to operationalize the emergence and evolution of 21st Century Competencies (21CC) in their class.

Major Goals of the ART Session

The objectives of the sessions are:

1. To present and explore a principle-based approach to co-analysis and co-reflection sessions by researchers & teachers in knowledge building classrooms in different context.
2. To integrate the existing analytical tools in KF6 based on feedback from teachers and come up with new design ideas
3. To consolidate a set of measures of 21st century competencies using KF and LA that can be adopted by schools.

Overview of the ART Session

In this session, we invite each Researcher-Teacher team to co-present the analysis of a Knowledge Forum database. The areas to be discussed at each presentation could include:

1. Learning analytics to support teacher and students in moving beyond prescribed curriculum
2. Learning analytics to inform teachers and students of principle-based pedagogical decisions
3. Embedded and transformative assessment of 21CC in KB classrooms

Below is an overview of each Researcher-Teacher team presentation (15 mins to present and 5 mins for Q&A):

1. Research-Teacher team from Ontario. This series of presentations will explore how LA enabled "just in time" pedagogical moves to support collective reflection and rich meta-talk around critical aspects of a KB community such as group connectedness, vocabulary use, and idea development. Classroom case studies will also explore how KF and LA were used as a means to engage with and deepen understanding of 21st century and global competencies such as developing norms of collaboration, digital citizenship, and creative problem solving. Emphasis will be placed on classroom implementation and ways practitioners (and their students) embedded LA in the daily work of the KB community as formative assessment of individual and group progress on these multiple fronts. A range of grade levels and subject areas will be represented, including math, social studies, business, English, and science from both elementary and secondary classrooms.
2. Research-Teacher team from Singapore. This presentation describes the analysis of a interdisciplinary project on Heritage. A collaboration between History and Music teachers in a Secondary School in Singapore. The project spans across two academic years. The use of the LA in this case touches on three areas: comparison of text-mining analysis in three corpus of text, the curriculum document, the students' discourse and lastly, journal articles on the content to allow for comparison and to identify gaps for further improvement. Researcher will present simple measures of students' participations, vocabulary growth, and idea-network growth, while the teachers (History and Music teachers) will triangulate the analysis with how they have interacted with their students and what they have observed in class.
3. Research-Teacher team from Minnesota. This presentation reports on a journey of introducing KB to high school science classrooms. In particular, based on multivocal analysis of several KF databases, we will share our experiences in assessing (a) students' *epistemic versatility* of as knowledge builders (defined as making different types of epistemological moves such as asking factual questions, asking explanation-seeking questions, finding limitations in theories, providing facts, creating explanations, using authoritative resources effectively, summarizing, and making meta comments on the discourse), (b) *social connectedness* in KB discourse, and (c) *cognitive diversity* reflected in the semantic makeup of their forum posts. All three aspects will be analyzed over the temporal dimension and correlated with one another. We will interpret findings from teacher-researcher perspectives and discuss implications for teaching and analytics design.
4. Research-Teacher team from Hong Kong. Low achievement students are often perceived as lacking of the capability to engage in high-level inquiry and learning process. This presentation describes whether and how these students can be involved in productive discourse with a focus on developing their conceptions of discourse using manual analysis and a small scale of Idea Thread Mapper (ITM) implementation. The study was conducted for Grade 10 students enrolled in a visual arts class at Hong Kong Band-3 (lowest-achieving band based students' public examination results) secondary school. In the presentation, research will report the analysis of students' work in KF and classroom talk, while the teacher will present how these analysis and the co-reflection was conducted by researcher, teacher, and students can help students engage in productive discourse further and deeper, followed by KB students' sharing on how the knowledge building help themselves to meet the global competencies.

Audience Engagement

Following the short presentations, the audience will be engaged in a Q&A session, when they can ask presentation-specific and general questions.

At the Q&A and discussion session is ongoing, the co-chairs will work with all symposium participants to generate the alignment across, 21CC competencies, teachers' pedagogical moves, students' learning moves, and learning analytics capabilities (see a sample draft of this alignment in table 1) from the presentation. The audience will then be grouped around related 21CC to discuss the potential and challenge of adopting such framing of KF and LA in schools. Google-spreadsheet will be used in this discussion. Each group will report back to the group and post a "rise-above" note to the conference's KF database.

Proposed Length of Session

Two consecutive 90 minute sessions in total: Each researcher-teacher team has 20 mins to present, 10 mins for Q&A. 30 mins for discussions on implications and design of LA in practice.

Proposed frame of discussion at the ART session

Table 1 An attempt to draw alignment from critical and inventive thinking to teachers' role, to students' role, to design and utility of learning analytics for sense-making in school.

21CC, Critical inventive thinking (CIT) and its sub-component	Teachers' Ped Moves	Students' moves made visible on KF	KF & L.Analytics
(CIT1) students exploring possibilities/ pathway and generating ideas in relation to issue/challenge	Understand curriculum document; identify concepts and big ideas Design Trigger/ create space for students to share ideas and to derive where to start	Students set forth their ideas (questions, information, theories)	1. Scaffold-Tracker
CIT 2: students exercising sound reasoning, decision making and metacognition	Systematically study students' ideas; provide space for students to read and understand and connect to others' ideas Gain general sense of collective inquiry process	Students put in effort to understand other's ideas in relation to the collective problem	1. Reading and Writing Network; *Scaffold-Tracker* 2. Vocabulary growth 3. Word cloud introduced in class discussion
CIT3 students managing complexities and ambiguous; suspend judgement and assess conclusions and consideration	Support students to identify promising ideas, e.g. provide criteria Support students' research Support students to create rise-above notes to synthesize best explanations	Students negotiate a fit between personal ideas and ideas of others	Network of ideas
		Students use contrasts/misfit of ideas to sustain the inquiry rather than depending on teacher to chart that course for them.	Social Network Pattern;

The Idea Thread Mapper Project: Sustaining Knowledge Building across Classrooms

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Abstract

Knowledge building requires students to take on collective responsibility for charting the course of sustained inquiry that involves multi-level dynamic interactions. We designed the Idea Thread Mapper (ITM) system to support student-driven knowledge building in each classroom community as well as idea interaction across communities. At a local classroom level, students engage in focused inquiry and discourse while carrying out metacognitive conversations to frame/reframe their collective inquiry directions and processes, and synthesize their inquiry progress over time. For cross-community interaction, they selectively share productive idea threads and syntheses in a cross-community space for idea contact with broader knowledge builders. Supported by ITM, we conducted design-based research in a set of Grade 3-6 classrooms to test and refine new classroom designs to support student-driven knowledge building within each classroom and idea interaction across classrooms. In this Innovative Format session, we will provide an overview and demo of ITM, reflect on a set of classroom cases, and discuss research findings and possible collaborations.

Keywords: Knowledge building, Idea Thread Mapper, Reflective structuration, Boundary crossing.

Vision and Challenges

To prepare students for creative careers in a knowledge-based society, schools need to cultivate collaborative inquiry practices by which knowledge-creating communities expand our society's knowledge (Barron & Darling-Hammond, 2008; Bielaczyc & Collins, 2006; Chinn & Malhotra, 2002; Edelson et al., 1999; NRC, 2000; Slotta et al., 2013). Knowledge-creating communities achieve productivity through sustained inquiry and progressive discourse by which ideas are continually developed, refined, and built upon, giving rise to higher-level conceptualizations and more advanced goals (Bereiter, 2002; Dunbar, 1997; Engeström, 2008; Sawyer, 2007). Such efforts are further supported by dynamic idea contact and interaction across communities, which work as an interconnected intellectual field (Csikszentmihalyi, 1999). Collaborative knowledge building in schools requires similar sustained, connected, and long-term efforts of students to be productive (Dean & Khun, 2007; Engle, 2006; Hakkarainen, 2003; Scardamalia & Bereiter, 2006).

Achieving the above vision of sustained inquiry and knowledge building requires new research and technology designs to address a number of intra- and inter-community challenges. First, within each classroom community, we need to explore new ways to support student-driven, long-term inquiry in which students enact high-level epistemic agency. Knowledge Building pedagogy (Scardamalia & Bereiter, 2006) adopts a principle-based approach that differs from scripted designs of inquiry topics, tasks, and procedures used by many collaborative learning programs. The principle-based approach to knowledge building embraces flexible classroom dynamics that are needed for creative knowledge processes in which students develop high-level agency (Zhang et al., 2011). To guide effective and broad classroom implementation of knowledge building, this principle-based approach needs to clarify how student-driven, open-ended, interactive inquiry processes can become socially organized and pedagogically supported while addressing curriculum expectations and contextual constraints (Zhang et al., 2018).

Second, to extend inquiry connections across classrooms, we need new designs to make each community's knowledge practices and progress accessible to other communities. In the current online systems, although student online discussions are automatically recorded, their knowledge advances achieved are hardly accessible to other communities. Online discussion spaces are typically reset for each new student cohort, dumping out the ideas of the previous students. There are emerging efforts to share online discussion spaces among different communities for collaborative knowledge building (Laferrière et al., 2012); however, students often find it difficult to read other communities' online discussions and understand their knowledge advances.

To address the above challenges, this research project designed a collaborative online platform: Idea Thread Mapper (ITM) (Chen, Zhang, & Lee, 2013; Zhang et al., 2012, 2018), which interoperates with Knowledge Forum (Scardamalia & Bereiter, 2006). Supported by ITM, we conducted design-based research studies to test and refine new classroom designs for supporting student-driven knowledge building within each classroom and idea interaction across classrooms. In this Innovative Format session at the KBSI 2018, we will provide an overview and demo of ITM, reflect on a set of classroom cases, and discuss research findings and possible collaborations.

Our Conceptual Framework Guiding ITM Design

In light of the aforementioned multi-level interactions for knowledge creation (e.g. Bereiter, 2002; Csikszentmihalyi, 1999; Dunbar, 1997), we designed ITM to enable sustained knowledge building in each classroom community as well as idea interaction across communities. At a local classroom level, students engage in focused inquiry and discourse in their own classroom's discourse space, carry out metacognitive conversations to reflect on shared focuses and insights emerged from the distributed discourse, and synthesize their threads of inquiry including the progress achieved and deeper problems to be addressed. For cross-community interaction, they selectively share productive idea threads and syntheses in a cross-community space for dynamic idea contact with broader knowledge builders. Across both social levels, students take on high-level responsibility for structuring their unfolding inquiry directions and processes, reviewing progress, and planning for productive actions and collaboration as their inquiry deepens.

Our conceptual framework guiding the above ITM design includes two key concepts: reflective structuration and boundary crossing in knowledge practices. First, our design to sustain knowledge building in each classroom adopts an emergent *reflective structuration* approach (Tao & Zhang, 2018; Zhang, 2013; Zhang et al., 2018). Different from pre-scripting collective inquiry using teacher-designed inquiry directions and processes, students engage in reflective processes as a community to co-construct collective inquiry structures to channel their personal and collaborative actions over time. The co-constructed structures represent shared interpretative frames of what the community should investigate, how research and talks should be conducted, and the participatory roles. Guided by the co-constructed structures, students engage in reflexive monitoring of the ongoing knowledge practices and develop coordinated efforts to advance their collective agenda without merely relying on the teacher to lead them through the whole process. As students' inquiry proceeds and new directions emerge, they adapt and reconstruct the shared inquiry structures as needed to support deeper and more advanced inquiry (Zhang et al., 2018). To support reflective structuration of knowledge building practices, ITM addresses incorporates a meta-layer of emergent inquiry structures in collaborative online environments, so students and their teacher can monitor emerging directions and co-construct shared inquiry structures over time. Current collaborative environments in the forms of online forums and chatting lack such support. With student ideas recorded in individual online posts in distributed discourse entries, it is difficult for students and their teacher to monitor the collective landscape (e.g., emerging directions and strands of inquiry) formed and altered through the distributed discourse and interactions in long-term inquiry (Hewitt, 2001; Suthers, Vatrapu, Medina, Joseph, & Dwyer, 2008). Without a clear awareness of their community's goals, directions, and progress, students' discourse entries are often ill-grounded and disconnected, lacking progressive deepening moves (Zhang, 2009).

On the basis of student-driven inquiry in each classroom community, ITM further approaches cross-community interaction through boundary-crossing objects (Zhang et al., 2017). Boundary-crossing objects are artifacts (e.g. reports, tools, models) used to bridge the boundaries (discontinuities) between different social worlds (Star & Griesemer, 1989). Objects from a community often have contextual meanings that are not accessible to other communities. What makes boundary objects effective for bridging different communities of practice is their interpretative flexibility as a "means of translation" (Star & Griesemer, 1989): they have a structure that is common enough to make them recognizable across the different social worlds and allow different communities to interact and work together. Row distributed discourse entries cannot be easily used as boundary objects; therefore, ITM uses high-level structural representations in the form of idea threads and Journey of Thinking syntheses as sharable boundary objects to make each community's work accessible. Through interacting with shared boundary objects, members from different communities can identify, understand, and reflect on their different practices, leading to enriched understandings within each community and potentially the creation of new, in-between practices (Akkerman & Bakker, 2011).

An Overview of the ITM Features

The main features of ITM are summarized in Table 1 and further elaborated below.

Table 1. *The Key Features of ITM to Make Collective Structures Visible.*

Key Feature	Description
Inquiry area and object organizer	A visual display of the major areas (e.g., circulatory system) and objects (heart, blood cells, lungs) of inquiry to organize a whole knowledge building initiative (e.g., the human body inquiry). Students propose the areas and objects of inquiry, with each object of inquiry becoming the focus of an idea thread.
Idea thread	Visualization of each unfolding strand of inquiry that involves a

	sequence of discourse entries investigating a shared object of inquiry, extending from the first to the last discourse entry. Students enter the focus (object) of inquiry, write or import the relevant discourse entries, which are plotted on a timeline as an idea thread. Analytic tools (e.g., search, topic modeling, contribution type analysis) are created to help students find and review relevant discourse.
Mapping different idea threads	Visualization of multiple threads and areas of inquiry to show the whole picture of a knowledge building initiative. Students select areas and/or threads to map and choose to show specific information such as cross-thread build-on links and "bridging notes" each belonging to multiple threads (talking about interrelated topics).
Journey of thinking synthesis	A "Journey of Thinking" document co-authored by students for each idea thread, which highlights the problem/goal of inquiry, "big ideas" learned, and deeper issues and actions to be pursued.
Participatory role tracing	Tracing of student specialization and contribution across inquiry areas and idea threads. Students select an area(s) of inquiry as his/her focus, with students of shared interests forming flexible collaboration ties. ITM further retrieves the members' participation in each idea thread as authors and readers.
Cross-community sharing and interaction	A cross-community space where students from different classrooms can view one another's inquiry areas, idea threads, and Journey of Thinking syntheses; and propose "super talk" topics to discuss challenging issues.

Note: Adapted from Zhang et al. (2018).

Features to Support the Reflective Structuration of Knowledge Building in Each Classroom

ITM supports the co-construction of shared inquiry structures in long-term knowledge building practices. The core functions focus on the needs to discover emerging interests and directions in students' interactive discourse, to formulate unfolding strands of inquiry through reflective processes, and to make such structures visible to inform student ongoing reflection and participation. In line with the framework of reflective structuration, ITM includes (a) spaces and tools for online discourse interaction through which students generate deepening questions and ideas; and (b) features for inquiry structure creation and visualization to capture emerging inquiry directions and co-organize the online discourse accordingly. The online discourse space in ITM interoperates with Knowledge Forum (Scardamalia & Bereiter, 2006) and potentially other platforms. Students contribute and build on one another's ideas in interactive discourse, with ideas presented in distributed postings (e.g., notes) and build-on responses. On top of the online discourse, the inquiry structure layer in ITM focuses on framing and mapping the unfolding strands of inquiry to address emergent objects of inquiry, tracing students' personal and collaborative roles, and documenting shared progress in each strand of inquiry over time to inform deeper future work.

Drawing upon the analytics developed in our prior work (Zhang et al., 2007), ITM organizes and visualizes each strand of inquiry as an "idea thread" (or "inquiry thread"). Each idea thread involves a sequence of discourse entries--possibly involving several build-on trees--that investigate a shared inquiry object (e.g., batteries) over a time period (see Figure 1). The closely related threads of inquiry further cluster into larger "wondering areas" in a complex knowledge building initiative (see Figure 2).

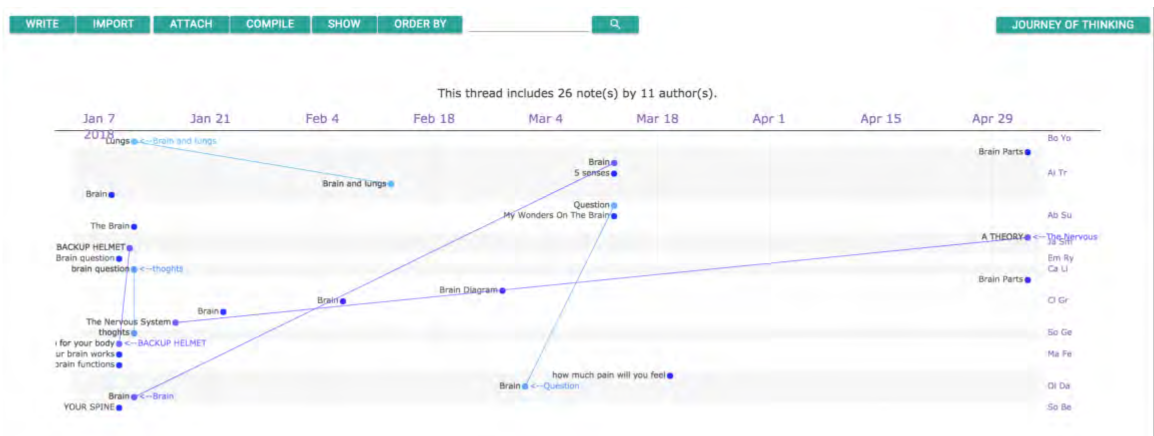

Figure 1. An idea thread developed by a Grade 5 classroom focusing on how the brain works. Each dot represents a note, and a line connecting two notes shows a build-on connection. The notes in the idea thread are displayed based on the time of creation (x-axis) and author (y-axis).

Figure 2. ITM's visual organization of wondering areas and idea threads. Each wondering area (e.g. Brain) is a major direction of inquiry. Each idea thread (e.g. How does the brain work to control the body?) investigates a more specific problem or challenge related to one (or more) wondering area. Right(Ctrl) click on the project to add

a wondering area (for the teacher to approve). Right(Ctrl) click on a wondering area to add an idea thread.

Both idea threads and wondering areas are emergent structures, which are formed like "desire lines" (as apposed to pre-planned paths) in the collective space and reformed as the inquiry deepens and expands over time (Zhang et al., 2018). In a knowledge building initiative, students begin with open exploration and discourse to develop initial ideas, questions, and research. Through monitoring emerging inquiry interests and evolving needs, they identify high-potential areas of inquiry and set up idea thread foci, within which they pursue joint inquiry to advance collective understandings while identifying deeper problems.

ITM includes analytics and tools to support these reflective efforts to identify, formulate, and adapt shared inquiry directions. Within each idea thread, the online notes and build-on responses are displayed on a timeline to make the temporal progress visible. Analytics show who is working on what thread(s) of inquiry over time. The contributors in each idea thread can co-author a "Journey of Thinking" synthesis to deliberate their progress over time, including the goals/problems, "big ideas" learned so far, and deeper actions needed. The "big ideas" learned are phrased based on "We used to think…now we understand…" See an example in Table 2.

Table 2. *An example Journey of Thinking written by a group of 5th graders in the idea thread about breathing.*

Questions explored:	[We want to understand:] how do the tissues use the oxygen? How and why do we breathe?
Big ideas learned:	[We used to think:]That there was not a big process to this. [We now understand:]We get oxygen from air we breath in. The oxygen goes through the thin walls of the air sacs. With the help of hemoglobin, oxygen passes through the air sacs into the blood vessels throughout the body. As that happens Co2 goes out of your body. …
Deeper research needed:	[We need to do more learning] about how air get around the body. [We need better theories about] Where is hemoglobin exactly located in the body and does it do anything else besides carry oxygen to the blood, and bring co2 back into the lungs. [We need to further understand] …more about tissues.

At a higher level, the collective landscape of a whole inquiry is mapped out as clusters of idea threads that investigate interrelated issues through the contributions of all the members (Figure 3). The map of idea threads further shows cross-thread connections, including build-on links among notes from different threads and connective "bridging contributions," each of which simultaneously investigates two or more topics as related issues. Analytics embedded in the map of idea threads provide feedback on the intensity and types of contributions made by different students over time.

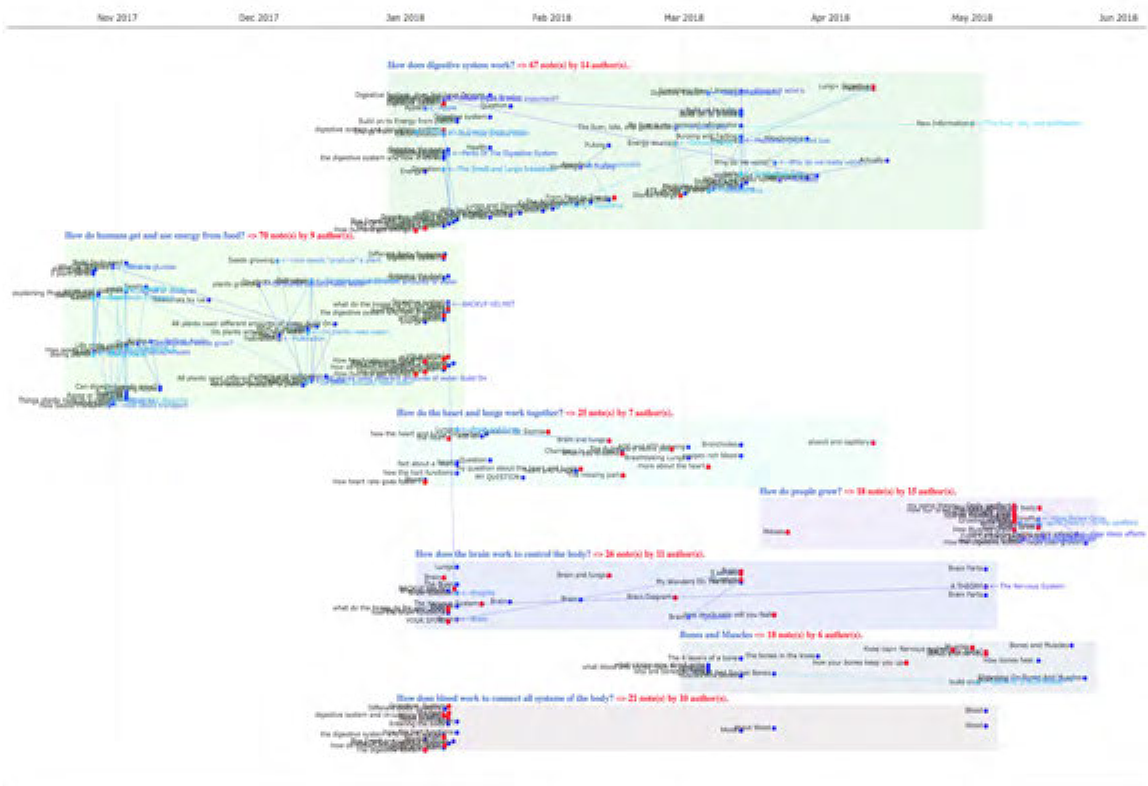

Figure 3. Mapping different idea threads on the same timeline. Each color stripe represents an idea thread addressing a principal problem. Each dot shows a note. A line connecting two notes indicates a build-on connection.

Features to Support Cross-Community Interaction

On top of the inquiry mapping for individual classrooms, ITM supports knowledge building interaction in a network of "buddy classrooms," which can view into each other's wondering areas and inquiry threads and also engage in live cross-community "super talk." The multi-level interaction design allows students to engage in focused inquiry and deepening discourse within their own community's space while sharing syntheses of Journey of Thinking with buddy classrooms, as boundary-crossing objects. Students from other partner classrooms (or a subsequent student cohort) can use the idea thread visuals and Journey of Thinking to view into the progress of inquiry and build cross-community connections. As a newly designed feature, ITM allows different classrooms to initiate and participate in live *"Super Talk"* to collaboratively address challenging problems at the intersection of the different communities' knowledge (Figure 4).

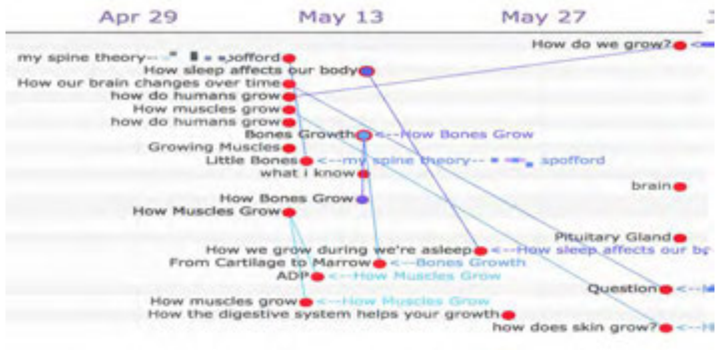

Figure 4. The cross-classroom Super Talk about how people grow among four Grade 5 classrooms studying the human body. Each dot shows a note, and line between two dots shows a build-on connection. Each note was position based on the date of creation (x-axis) and author (y-axis).

Classroom Research and Findings

Our team has conducted a set of design-based research studies to explore ITM-supported classroom processes of knowledge building and examine students' collective and personal knowledge outcomes (Zhang et al, 2013, 2014, 2017, 2018).

ITM-Supported Classroom Processes

In each knowledge building initiative that investigated a core science topic over multiple months, students carried out various inquiry activities and participated in extended knowledge building discourse to deepen their understandings. ITM-enabled classroom designs focus on engaging students' reflective efforts to (a) co-construct/reconstruct shared inquiry structures (inquiry areas and directions, process guidelines, social roles) as their inquiry continually deepens/expands; and (b) build fruitful idea connections with their buddy classrooms for mutual learning and build-on. Figure 5 provides an overview of the typical classroom processes. At KBSI, we will elaborate the classroom processes using a set of classroom cases.

Figure 5. ITM-supported classroom processes for sustained knowledge building.

Research Findings

The results of these studies suggest that the third- to sixth-graders were able to conduct meaningful reflective conversations to co-frame shared directions of inquiry and organize the related knowledge building discourse, although the third-graders needed more guidance and support from their teacher. Analyses of the online discourse and student interviews suggest a number of potential benefits: through ITM-supported reflective review and structuring of inquiry, students developed a clearer and broader awareness of their community's foci and progress in the whole inquiry beyond student personal focus and interest. Their online discourse also became more connected with more interactive build-ons (Zhang et al., 2013, 2016, 2018). Compared to their questions raised in regular online discourse, students also generated deeper questions in their Journey of Thinking syntheses, seeking explanations of underlying mechanisms beyond basic facts (Zhang et al., 2013, 2014). Content analysis of student summary of what they had learned show that students engaging in ITM reflection achieved a higher level of complexity and connectedness in their scientific understanding than those in a comparison condition (Zhang et al., 2018).

We further tested cross-classroom interaction for knowledge building (Zhang et al., 2017, 2018). Our first iteration of this design-based study in this area was conducted in two grade 5/6 classrooms that studied human body systems over a 10-week period (Zhang et al., 2017). As the students conducted focused inquiry and discourse within their own community, they reviewed productive threads of ideas and posted "journey of thinking" syntheses in a cross-community space. The syntheses, which were called "super notes" by students, were written by students using ITM's "journey of thinking" scaffolds: Our problem, We used to think…and now we understand…, We need deeper research. A set of "super notes" syntheses from previous classrooms studying human body systems was also posted in the cross-community space. The analyses of the classroom discussions and student interviews suggest that the students engaged in active and substantial interactions with the "super notes" from other classrooms, with more attention paid to the "super notes" created by their partner classroom than those from prior classrooms. Students identified relevant and interesting super note topics from other classrooms, compared the different perspectives and inquiries, triggering deep reflection on their own inquiry to integrate and build new knowledge across communities. Further iterations of this design-based research expanded the cross-classroom interaction to more classrooms, with more detailed analysis of the interaction patterns (Zhang & Yuan, 2018).

Conclusions and Implications

The ITM design and related studies contribute new strategies to addressing the intra- and inter-community challenges essential to implementing and sustaining knowledge building across classrooms. The combination of the technology advances and classroom designs shed light on new socio-technological infrastructures for enabling networks of knowledge building communities, each of which engage in continual idea advancement while building on the knowledge work of other communities.

Particularly, this project offers a reflective structuration approach to implement collective inquiry and knowledge building for classroom transformation. In an inquiry-based initiative (unit) that may extend over multiple weeks or months, the teacher can work with his/her students to co-structure their collective journey of inquiry over time without extensive pre-scripting. High-level issues, such as what to investigate, through what processes, by whom/with whom, can be co-structured by students with the teacher as the inquiry deepens over time (Zhang et al., 2018).

This research further offers a multi-level emergence design of cross-community interaction. While students engage in focused inquiry and discourse within their own classroom, they generate reflective "Journey of Thinking" as boundary-crossing objects and participate in the "Super Talk" to investigate a challenge problem together. Students build on new knowledge gained through the cross-classroom collaboration to extend and enrich their own inquiry and discourse in their home class.

The pedagogical framework and ITM system inform new opportunities for designing knowledge building tools and analytics and creating/accumulating shared infrastructures to help broad classrooms transform into connected knowledge building communities. We seek collaborative input from other researchers and practitioners to work together on possible future initiatives. These may include efforts to (a) design and integrate various analytics in the context of idea threads and in the cross-community space to trace long-term knowledge building progress and interactions; (b) use ITM as a pedagogical co-organizing support to implement knowledge building in broad classrooms and support teacher development using annotated classroom cases, materials and tools; and (c) design and test cross-classroom collaboration among an international network of knowledge building communities that build shared knowledge focusing on key social and scientific issues of global interests.

Acknowledgements

This research was sponsored by the U.S. National Science Foundation (IIS #1122573, IIS #1441479). We owe special thanks to our collaborating teachers and students for their creative work enabling this research; and to our team members for their contributions to the software development, classroom research, and data analysis.

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Posters

The ‘Progressive Design Method’ Development: How to promote Students’ Participation in Blended University Courses

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Lens of a Knowledge Building practitioner: Enhancing Teaching and Learning of Music

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Abstract. This poster describes an action research on the pedagogical innovation in music class (lyrics writing) based on the knowledge building (KB) principles. The lyrics written by students on the theme of 'Heritage" in a KB class and a traditional music class is coded for the depth in terms of (i) vocabular; (ii) sentiment expressed; (iii) multiple-perspective. There was a significant improvement in both sentiment and multiple-perspective taking in the kb class.

Introduction. Music education in Singapore is currently placing greater emphasis and focus on songs creation and composition. Various songwriting competitions such as our annual "*National Schools Xinyao*[1] *Singing and Songwriting Competition*" has been organised. Schools have been actively participating in these events. While having this trend is encouraging and promising for the music teachers, however there is a genuine concern on students' understanding and mastery of the complexity behind lyrics construction.

Problem Statement. Students are not able to relate to the lyrics of the song that they are learning, crafting and/or performing. When writing lyrics, students generally find it difficult to express themselves through relevant vocabulary, due to the lack of conditioning and exposure. According to Marlene Scardamalia, socio-cultural aspects ideas are best generated through experiential learning (Scardamalia, 2002). As such, the teaching and learning of lyrics writing must be appropriately scaffolded within a community-orientated, empathic-driven and active learning cycle setting. Knowledge Building Pedagogy (KB) with its key emphasis on idea improvement facilitates this practice well.

Design and Implementation. In Teck Whye Secondary School, the team aligned the Knowledge Building Pedagogical framework and the process of lyrics construction as seen below:

KB Pedagogical Framework	TWSS Lyrics Writing Processes	Detailed Explanation
Idea Generation	Expose and Experience	Students are expected to generate their own personal thoughts with regards to the topic/theme. This can take in the form of vocabulary, questions, images and emotions. Research and Learning journey might be used to faciliate this process.
Idea Improvement	Exchange and Enhance	Students are expected to share their thoughts and views to others via Knowledge Forum. In the process, they are also expected to provide ideas, comments and suggestions to enhance, strengthen and develop the entries/ideas of others. Working in this environment of collaborative learning helps the students to broaden and deepen their perspectives, accuracy and emotions towards the topic/theme.
Idea Synthesization	Combine and Connect	Students are required to think of ways and approaches to synthesize the varied opinions, perspectives and ideas in generating their song lyrics ranging from the title to the choice of words used.
Idea Reflection	Reflect and Recognize	Students are required to reflect on and trace their own growth in lyric writing. This helps to strengthen and reinforce their understanding behind the dynamics of song composition.

[1] *Xinyao* is a genre of songs unique to Singapore, which emphasises on expression of emotions and thoughts of Singaporeans.

Method. This study focuses on comparing the quality of lyric produced by students in 2 classes of similar student profiles: one class adopted the Knowledge Building pedagogy and technology and the other with traditional music pedagogy. The implementation spans across two semester (6months). The quality of lyrics is measured in terms of its 'depth' as indicated by (i) basic/advanced vocabulary used; (ii) mutltiple-perspectives; (iii) sentiment expressed within lyrics.

Findings and Conclusion. The team coded the lyrics from the two classes and reported on the positive impact KB has on the multiple-perspectives taken by students as well as the sentiment expressed by students. We are confident that music educators will see the power and necessity of using Knowledge Building Pedagogy in the teaching and learning of music composition.

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Knowledge Improvement Cycle and Map: Scaffolding the Grasp of the KB Principle, Improvable Ideas, Through Visualizations

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The Problem and Research Goals

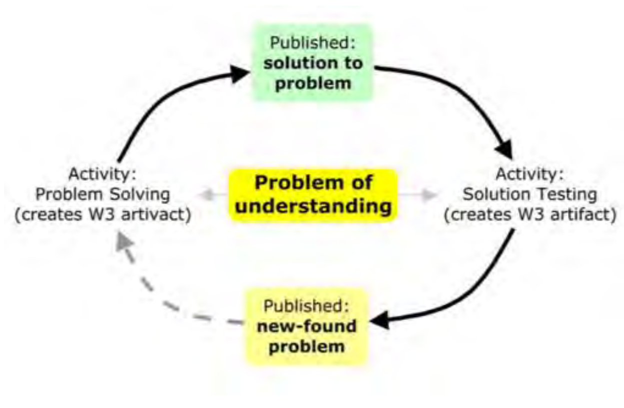
Knowledge improvement -- the central principle of knowledge building (KB) -- is clear; it is about making explanations more encompassing, effective and eloquent. Yet, the process by which this improvement is realized has generally not been expressed in a way that can scaffold teachers and students in this enterprise. The 12 Principles of KB are useful in guiding curricula, research and professional development, but not for teachers and students while in the milieu of KB. The scaffolding available to these practitioners is usually embedded into the KB software: "scaffolds" in Knowledge Forum and "knowledge types" in the Future Learning Environment. While these prompts or sentence starters are effective in channeling students' thinking and participation in KB discourse, there is no simple, "rise-above" explanation of how these sentence starters can fit together in a (non-prescriptive) process of knowledge improvement.

The goal of this philosophical inquiry (i.e. an inquiry based on theoretical arguments not empirical arguments) is to provide mid-level scaffolding – between the high-level "12 Principles" and the low-level "scaffolds" – that satisfies the need of students and teachers to understand and visualize the process of knowledge improvement. Its aim is to be of practical use to teachers and students and perhaps others in their pursuit of advancing the practices of KB in schools.

Knowledge Improvement Cycle

Science is often considered a problem solving activity (Pierce, Dewey, Popper, Hanson, Kuhn, Lauden, Freyerband). Popper (1972) developed a representation of how science solves problems using an error-elimination process which is sometimes been given an iterative representation. Certain kinds of problems or, as labeled by Bereiter (2002) and others, "objects of inquiry" are at the center of our activity as scientists. Bereiter applies Popper's 3-World ontology and considering World 3 as the central site of knowledge work and with Scardamalia, developed the ideas of Knowledge Building. Hakkarainen and Sintonen integrate the idea of the Interrogative model of Inquiry (the view that scientific inquiry is a progressive question/answer dialog with nature) with the idea of KB, and developed the idea of progressive inquiry, a processual model of enacting KB in the classroom community. And finally, Perkins argues that we ought to consider knowledge, from phone numbers to atoms to the theory of evolution, as designs, and Bereiter furthers this with the idea of World 3, allowing him to explain that KB is done mostly in "design mode".

Combining the ideas of KB with (1) the Interrogative Model's processual idea of science as a questioning/answering interplay with (2) the idea of knowledge as design, we can conceive of knowledge improvement as problem-centered knowledge work with an iterative design cycle, the *Knowledge Improvement Cycle* (KIC) (shown to right). A visualization called the *Knowledge Improvement Map* (KIM) addresses the problem inherent in using a cyclical representation to show problem-transformation i.e. that, once addressed, one never returns to the same problem from which one started. In other words KIM can be used to represent unlimited, actual KB discourse through its a flexibly emergent branching structure, composed of KIC's.



Language-appropriate versions of the KIC have been used to successfully introduce knowledge building to science teachers and students. Students familiar with an engineering design cycle appreciate hearing the idea that the "published solution" is like a prototype that can then be tested to see how well it works to solve the knowledge problem, if it makes sense, or even if it is an elegant solution. Furthermore, the KIC and it application in a KIM, have been used in a screencast for a few years by one of the authors to present actual student KB discourse to help students understand the KB principle of improvable ideas. In this screencast, students sought to understand a classmate-posed problem, “Why are aphids green?”

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Knowledge Building: Indices of Impacting Builders to Assess the Collective Cognitive Responsibility

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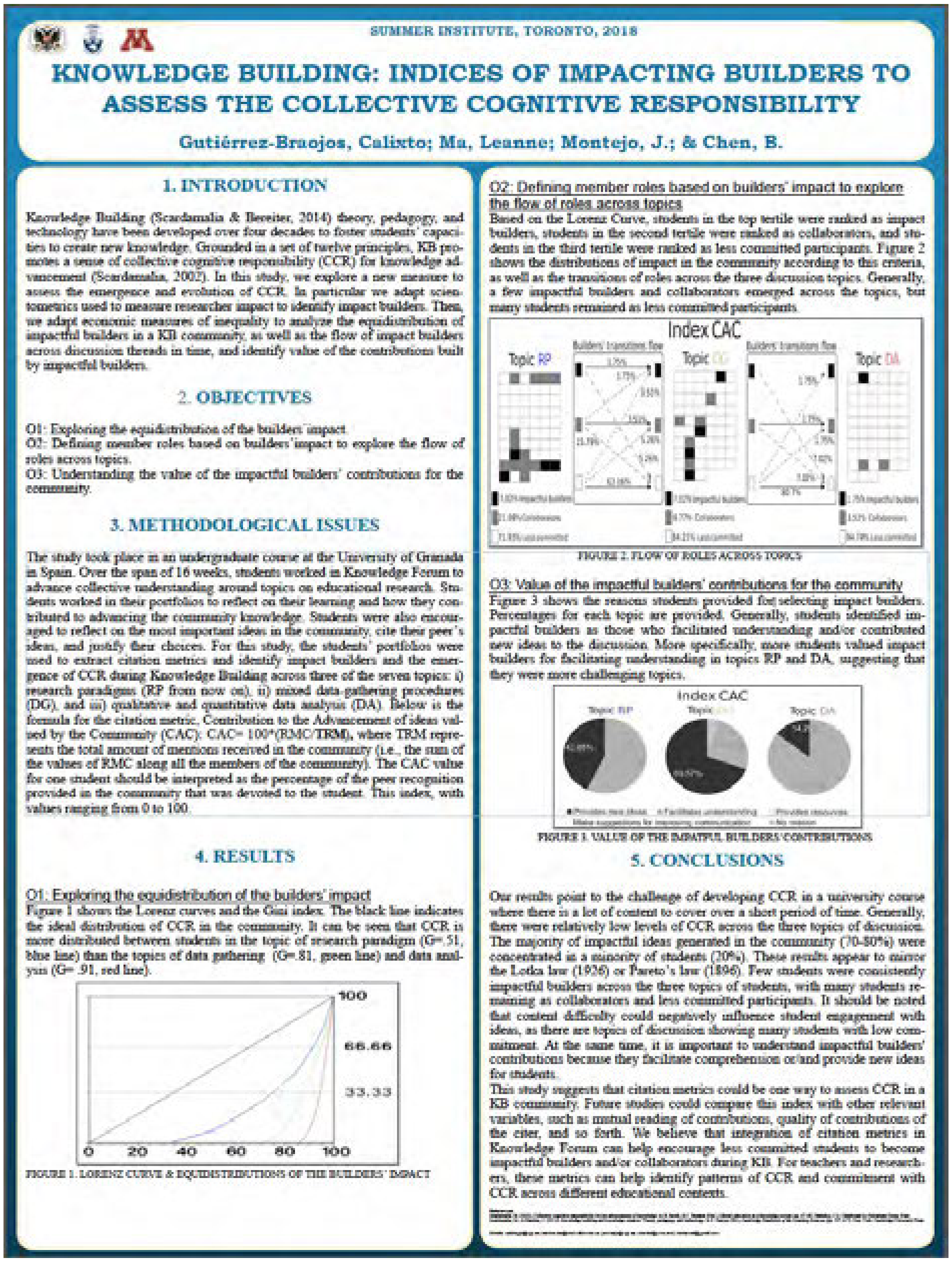

Knowledge Building research: Transience, continuance and core authors

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UNIVERSIDAD DE GRANADA

2018 Knowledge Building Summer Institute
TORONTO, 14-17 August

Knowledge Building research: Transience, continuance and core authors

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Introduction

Knowledge Building (KB) theory, pedagogy, and technology have been developed over the past several decades to enhance students' capacities to create new knowledge and to engage in sustained creative work with ideas (Scardamalia & Bereiter, 1994).

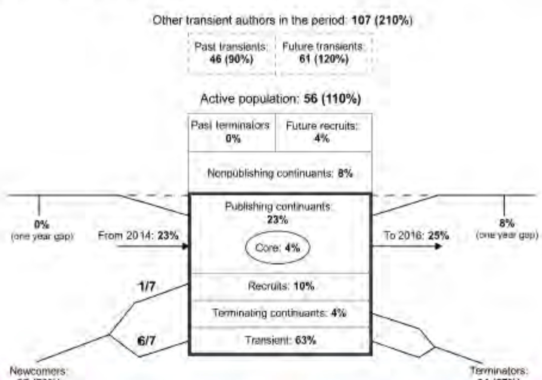
Objectives, method and sample

In order to understand the dynamics of production during the years 2013-2017, the authorship model proposed by Price (1986) is used. In this way, we focused our attention on 2015 and studied the population of authors and the flows of authorship.

Results

Publishing authors in the interval is distributed in two main categories:

I) The first one is composed of the 51 publishing authors who contributed at least one paper in 2015. Within this group, there are 12 publishing continuants, who published at least one year before and after 2015. There are also 37 newcomers, who are new publishers. Among these, we can find 5 recruits who published at least one other year after 2015, and 32 transients who published that year and never again. The publishing authors' category is completed with 2 terminating continuants, who were continuants in previous years and published that year but will not publish anymore. Terminating continuants along with transients make up the 'terminators' group of authors who finished their publishing activity in 2015. II) The second category to consider is composed of researchers who published in the period but did not contribute in 2015 (the remaining 117 authors). Within this group, there are 3 non-publishing continuants, who did publish in a previous year or in a subsequent one. Publishing authors in 2015 plus non-publishing continuants make an active publishing population of 56 KB researchers between 2013 and 2017. Apart from this population, there is a large majority of past (46) and future transients (61), who published just one paper in the period taken into account. We can also find 2 'future recruits', who started to publish in 2016 and also contributed in 2017. However, data do not show any 'past terminator'.



Conclusion

In sum, the dynamics of authorships show a small number of core publishing authors, very high levels of transience, and moderate levels of continuance, i.e, last means show a rotation authors.

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Contribution to the Archaeoschool Virtual Museum through the incorporation of a Baroque Hall with representative objects from the Cholula area, located in Puebla, Mexico

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Keywords: *Knowledge Building, Knowledge forum, baroque, virtual museum*

As technology progresses, the need to develop digital literacy strategies inside the classroom increases. As educators, the involvement in international projects allow us to engage our students in meaningful real-life experiences where the relevance of research and literacy skills merge in a digital environment. The incorporation of a Baroque Hall within the Archaeoschool Virtual Museum is a project that seeks to encourage research skills in middle school students in a formal and informal context by means of applying different technologies to catalog representative objects of archaeological sites in the Cholula area. In order to fulfill our goal, we focus on four KB principles: Real Ideas-Authentic Problems; Idea Diversity; Pervasive Knowledge Building and Democratization of Knowledge.

For the Baroque Hall curatorship, the students carried out an online academic research on the Baroque as a cultural movement, the relationship with the religious congregations established during the Spanish Colony in Mexican territory and its repercussion in their community. A field research followed up, with guided tours to representative places of the Baroque in Puebla. During this first year, we visited three churches: 1) *La Capilla del Rosario* at *La Iglesia de Santo Domingo*, 2) *La Iglesia de la Compañía de Jesús* and 3) *Santa María Tonantzintla*. The students gathered information *in situ* through photography and video, that was later reviewed and classified. Throughout this process a KB Forum was implemented by the students of both colleges, *Collegi Sánt Pau Apóstol* in Barcelona, Spain and San Diego School in Cholula, Mexico. This led to an enriching exchange of ideas between peers and allowed the comparison with the Spanish Baroque.

The preliminary results showed that the implementation of a project with international forecast, as well as the KB forum enabled the pupils to actively engage in knowledge discovery within their community. As a long term project, we look forward to improve the Archaeoschool Virtual Museum´s collection of Mexicans archeological sites. For a future stage, we will continue to focus in the four KB principles mentioned before while developing a new hall focused on prehispanic murals.

Knowledge Building in a Parenting Education Community

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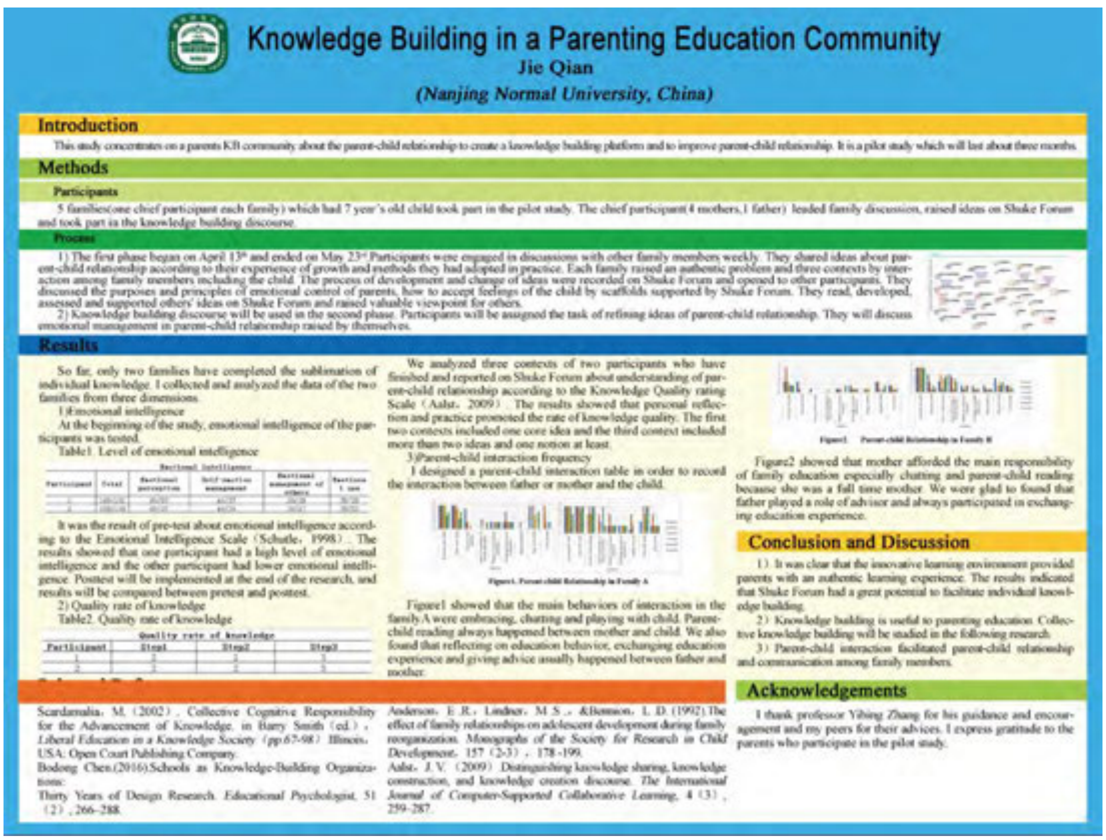
Abstract: Current approaches in parenting education emphasize the importance of designing communities of practice to support both formal and informal knowledge acquisition. Based on principles outlined by Scardamalia, the current study presents the design of a knowledge building community for parenting education. This study also aims to explore which interaction mode in the learning community contributes to the individual and collective knowledge building. Five families with one child at the age of 7 (one primary participant per family) participated in the study. The five primary participants (4 mothers and 1 father) led family discussion, raised ideas in Shuke Forum, and took part in the discourse of knowledge building. The results indicated that 1) Shuke Forum had a potential to facilitate individual knowledge building, 2) knowledge building was useful in parenting education, and 3) parent-child interaction facilitated the parent-child relationship and communication among family members.

Keywords: Knowledge Building, Parenting Education, Shuke Forum



Knowledge Building and Vocabulary Growth in English: A Case Study

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Vocabulary knowledge plays a crucial role in verbal and listening skills, reading comprehension, and learning of new concepts (e.g., Biemiller, 2005; Steahr, 2009). The sociocultural perspective on learning, based on Vygotsky (1978)'sociocultural theory of learning, highlights that all learning, including language learning, is achieved through social interactions with more proficient peers. Knowledge Building theory and pedagogy engages students in social interactions, in which students engage in *Knowledge Building discourse* to *transform and create* knowledge through progressive discourse (Scardamalia & Bereiter, 2006). Within the context of Knowledge Building, some studies (e.g. Chen, Ma, Matsuzawa, & Scardamalia, 2015; Sun, Zhang, & Scardamalia, 2008) examined vocabulary growth in subjects like science and social studies. However, the present research is the first attempt to study whether social interactions in English help students learn more advanced words or not, and whether knowledge building in English happens.

The dataset used for this study is comprised of Grade 4 students' discourse in English as archived in Knowledge Forum®. The data analyzed included a series of compositions and inquiries posted by 14 students over the course of 5 months. Students were asked to write compositions and to provide other students with feedback on their compositions. We analyzed the notes posted in the first month, notes posted in month 2 and month 3, and notes posted in month 4 and month 5. In order to analyze the notes, we used the Vocabulary Expansion Accelerator (VEA) tool which can identify the most 3000 common English words used in a text. The most 3000 common English words are the most frequently used words in everyday English conversations, based on statistical analysis. To analyze students' work, we traced the percentage of the most 3000 common words students over these 3 periods of time (month 1, month 3, month 5).

Figure 1 shows the preliminary results of the analysis. As this figure shows, For all the students except two the percentage of the most 3000 common English words students used in their notes is decreasing over time, indicating they tended to use more uncommon and advanced words. This can be an indicator of their vocabulary growth. For example, as can be seen in Figure 1, the percentage of the most 3000 common words student 1 (S1) used was 55.8%, 48.6%, and 36.4% for month 1, month 3, and month 5, respectively. This means in the first month, 55.8% of the words that student used in his/her composition were among the most 3000 common words, while in month 5, only 36.4% of the words used by that student were among the most 3000 common words. In fact, the results show that over time, students used fewer words from the most 3000 common words list, which means they used more advanced words.

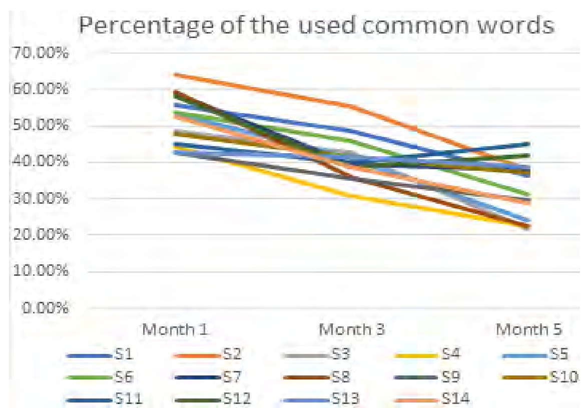

Figure 1. Percentage of the used 3000 common words

For the future work, we aim to replicate the study with more datasets. We also tend to examine if there is any correlation between note reading/note writing and using advanced words (i.e. not using common words). Besides, we are planning to do analyses on readability and complexity of students' compositions, and trace how the readability, complexity and the use of vocabulary change over time.

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Engaging students in Authentic Science through Knowledge Building using Virtual World

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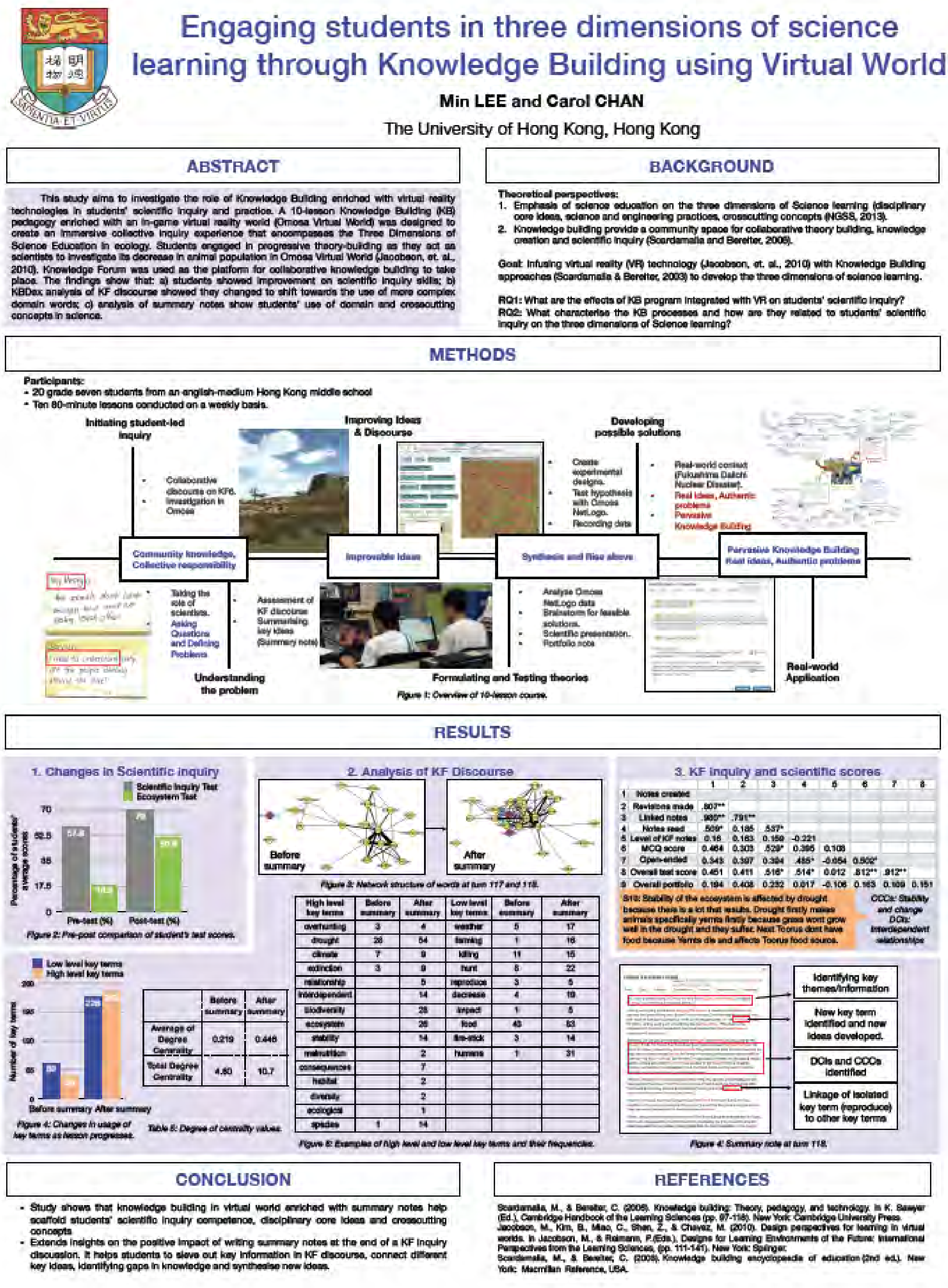

5th graders building knowledge in a science class

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5th Graders Building Knowledge in a Science Class

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Abstract

In this study, we tried to explore ways to engage 5th-graders in collaborative knowledge building (KB) and learn about energy saving. Findings indicate that students were able to collectively construct rich knowledge about energy saving.

Introduction

Group-driven, collaborative learning requires highly structured group activities, such as division of labor and scripted role-play in order to ensure efficient collaboration. In addition to group-based collaboration, Scardamalia and Bereiter (2006) argues that young students are capable of work collaboratively beyond groups, by embracing more emergent, non-group-based collaborative learning during which they may group and re-group community members based on similar inquiry problems and interest. The purpose of this study was to investigate whether engaging elementary students in KF as a knowledge building environment would help them collectively develop better knowledge and deeper understanding regarding the scientific topics inquired (i.e., energy-saving).

Research Method

Participants 34 grade-five students in an elementary school in Taipei, Taiwan

During A school year

Inquiry topics Greenhouse effect and energy conservation

Affordance 12 laptops could access to Internet to work with inquiry ideas in KF.

Analyses

(1) Idea-related activities: social talk, idea generation, idea sharing, and idea improvement (Hong & Sullivan, 2009)

(2) Creativity: fluency, flexibility, originality, and elaboration (Guilford, 1967)

(3) Final assessment : richness of the description (based on number of concepts, reasons, and strategies provided) and depth of understanding (based on the detail elaborated).

Results

Figure 1 showed students' online activities and creativity performance:

(1) The use of less productive activities, such as social chatting, decreased gradually from stage 1 to stage 2 (t = 2.63, $p < .05$).

(2) The use of more productive activities, i.e., idea improvement, progressively increased from Stage 1 to Stage 2 (t = -3.90, $p < .001$).

(3) Idea-related activities, i.e., idea-generation and idea-diversification, were found the amount of these activities remained consistent (t = 0.21, $p = 0.84$ for idea generation; t = -1.17, $p = 0.25$ for idea diversification) from Stage 1 to Stage 2.

(4) Four aspects of creativity were also assessed. It was found that all four aspects of creativity were significantly enhanced from Stage 1 to Stage 2 (t = -5.65, $p < .001$ for fluency; t = -6.45, $p < .001$ for flexibility; t = -2.15, $p < .05$ for originality; t = -5.37, $p < .001$ for elaboration).

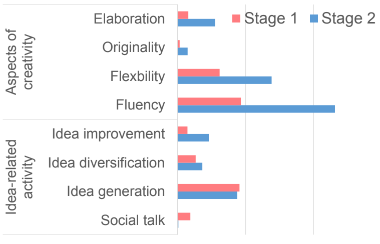

Figure 1

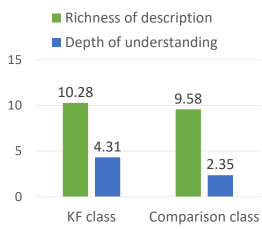

Figure 2

Figure 2 showed students' final-term assessment:

(1) The richness of topics descriptions between knowledge-building class and comparison class who engaged in group-based collaboration is not significant (t = 0.60, $p > .05$).

(2) The depth of understanding through assessing students' elaborated explanations, it was found that the knowledge-building class outperformed the comparison class (t = 3.32, $p < .05$).

Conclusion and implications

(1) Students' online interactions in KF indicated that they were able to work collaboratively with ideas as a community. Students could read, co-author, and build on each other's ideas in the form of notes.

(2) Under the pedagogical guidance, students were able to exert higher-level thinking skills to enable sustained idea interaction and even progressive idea improvement, as evidenced by the enhanced quality of idea improvement.

(3) The richness of subject content covered in KF was found that the concepts inquired online by these grade-five students were comparable to, and even richer than, the subject content suggested for middle-school students by an MOE's curriculum guideline.

(4) The knowledge-building class outperformed another comparison class taught by the same teacher using group-based learning, in terms of the final end-of-class assessment. Additionally, the students from knowledge-building class also demonstrated improved creativity skills.

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Exploring Novice Teachers' Reflections and Design Practices on Knowledge-Building in Junior High School Classrooms

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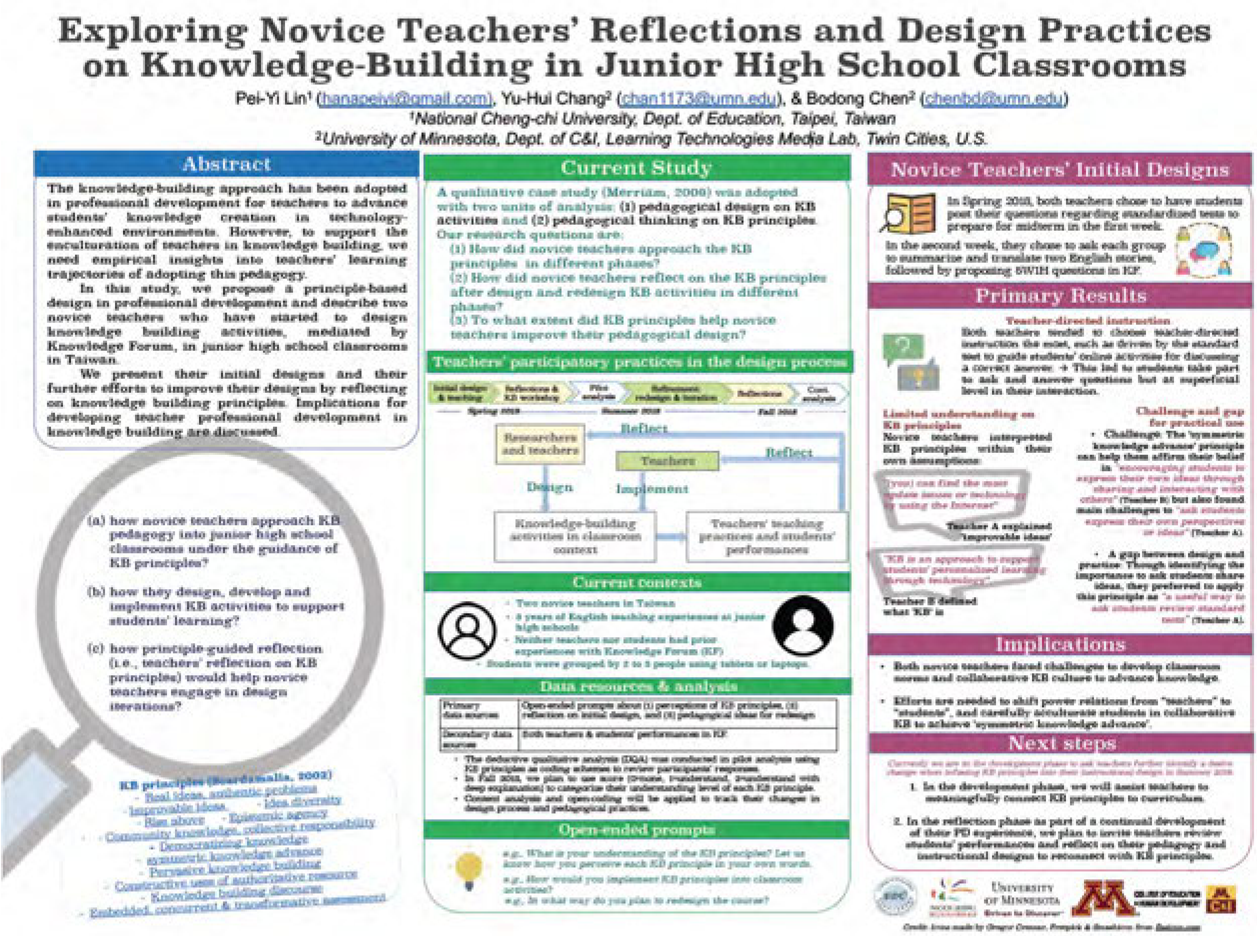
Abstract: The knowledge-building approach has been adopted in professional development for teachers to advance students' knowledge creation in technology-enhanced environments. However, to support the enculturation of teachers in knowledge building, we need empirical insights into teachers' learning trajectories of adopting this pedagogy. In this study, we propose a principle-based design in professional development and describe two novice teachers who have started to design knowledge building activities, mediated by Knowledge Forum, in junior high school classrooms in Taiwan. We present their initial designs and their further efforts to improve their designs by reflecting on knowledge building principles. Implications for developing teacher professional development in knowledge building are discussed.



Knowledge Forum as Qualitative Research Platform

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Research Summary for this Poster/Exhibition

Knowledge Forum is the software system which has been used in Knowledge Building (Scardamalia & Bereiter, 2006) community all over the world. Since Knowledge Forum version 6 was developed using modern web technology in 2014, the server instances have been deployed over continents, Knowledge Builders can access cyber Knowledge Building spaces using their own digital devices from wherever on the earth in the internet reception.

Recent major expectation to technologies in the Learning Sciences has been its use for learning analytics. In Knowledge Building community, quite a few research papers have been published by quantitative data collection and visualization using computing technology. Although the most studies adopted mixed-method approach, qualitative portions of the studies were conducted in a manual way.

Knowledge Building can be considered an attempt to emerge knowledge creating organization in an educational environment (Chen & Hong, 2016). A research lab is supposed to be a typical knowledge creating organization, and any kind of research activities is intended to knowledge creation in professional. In this research, we assumed qualitative consideration in the educational field research as Knowledge Building for researchers, then how we can support the activity using Knowledge Forum(KF).

In this exhibition, two ongoing projects will be presented. The mockups of the two tools are shown in Figure 1. One is (a) 4D discourse exploring tool. The tool not only visualizes a history of a view creation in animated fashion, but also visualizes the 3D model of the rise above structure. Another is (b) video analysis tool. The tool was initially designed for field researchers in elementary programming education. The users can easily, immediately upload videos which are taken in their education field by their own mobile device. The videos can be collaboratively analyzed, being annotated and finally represented as KF notes. It is considered as collaborative version of the proposed video analysis tool for educational discourse (e.g. Gregory et, al., 2009).

(a) 4D discourse exploring tool

(b) Video analysis tool for educational field research

Figure 1. The mockup images of the presenting tools.

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Designing for Knowledge Building: An Action Research Study in an Elementary Classroom

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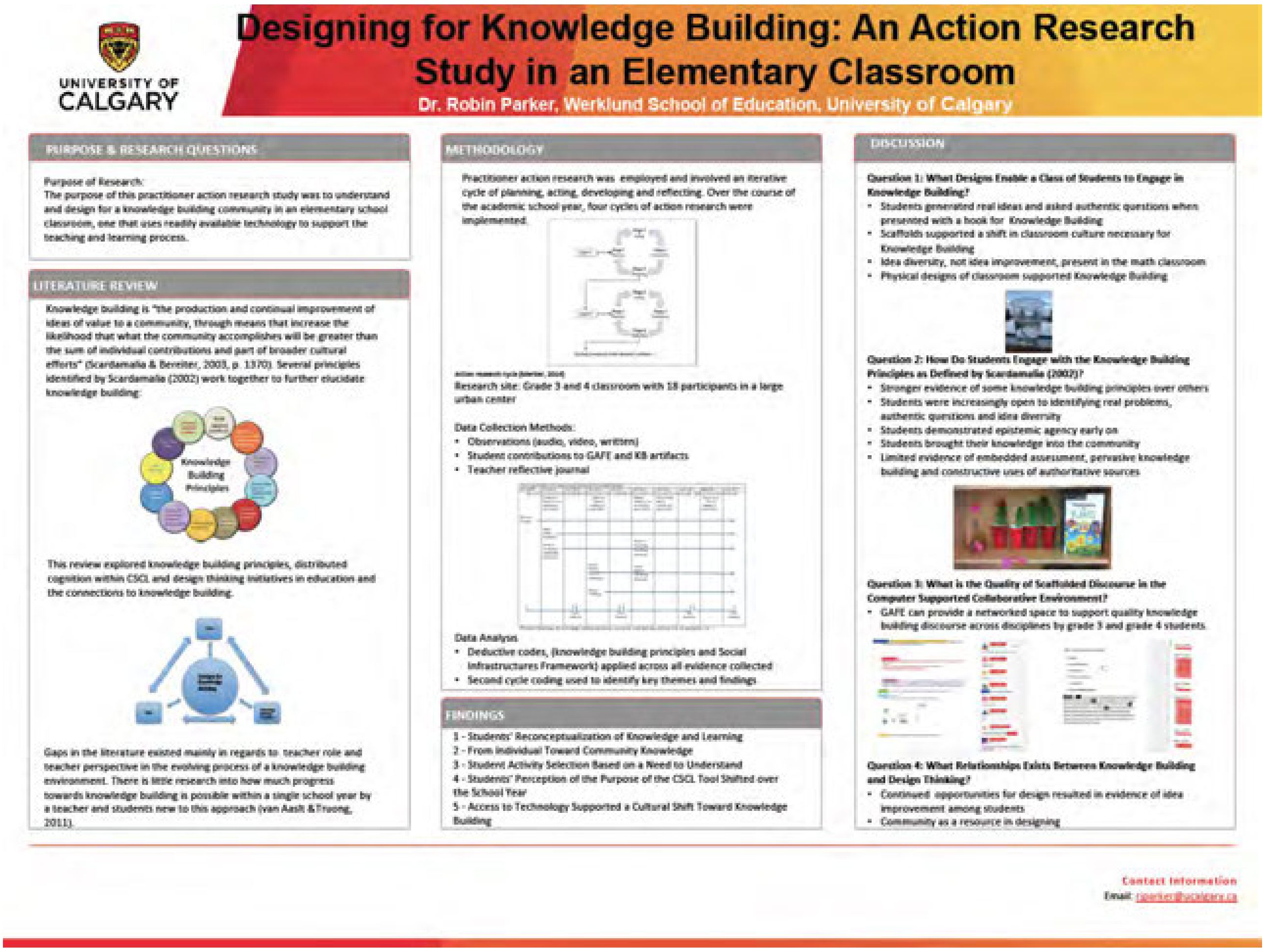

Knowledge Building and Professional Learning

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Teacher leadership involves teachers working individually or collectively to influence others to improve teaching and learning practices for the purpose of increasing student achievement. Teachers regularly share educational values, collaborate, engage in reflective dialogue, focus on student learning outcomes and strategies for improvement, and de-privatize their practice through peer observations. The Teacher Learning and Leadership Program (TLLP), advocated by a partnership between the Ontario Teachers Federation and the Ontario Ministry of Education, is an excellent example of teachers working collaboratively to solve problems and design innovative solutions. The Professional Learning Framework for the Teaching Profession (2016) also supports professional learning for informed and effective teaching practice through research and collaboration.

The Issue:

Teachers require time and space to discuss and reflect upon issues presented in their practice. Technology facilitates the communication process and affords teachers the opportunity to share their ideas. In particular, knowledge-building technology is an additional means for professionals to describe, analyze, and create. Teachers could further empower students to develop 21st Century competencies evident in their own professional learning communities.

Goals:

1. Promotion of knowledge building practices for school based professional inquiry.
2. Union advocacy for knowledge building practices in teacher inquiry as evidenced in the Teacher Learning and Leadership Program.

Addressing the issue:

Review of practices used within the Teacher Learning and Leadership Program demonstrated use of knowledge building strategies and deep inquiry. Through collaboration and problem solving, teachers created innovative solutions to real life practical concerns. Many TLLP participants have become leaders through their research and practice by mobilizing their knowledge across classrooms, schools, boards, and internationally.

Research Advances:

Knowledge creation and knowledge building research is relevant to TLLP group activity.
Van Alst (2009) distinguishes between the levels of constructivism: knowledge sharing -transmission, knowledge construction - constructivism, knowledge creation, and knowledge-telling. Teacher Learning and Leadership projects highlight varying levels of knowledge discourse with some extremely successful innovations in instructional practice.

Next Steps:

Through reflective practice and dialogue, teachers could delve more deeply into their own professional learning and communal concerns. Campbell, Lieberman, and Yashkina (2017) reported that many TLLP teachers were unfamiliar with the TeachOntario online learning environment, yet they were willing to participate and share resources. Knowledge building strategies and technology such as Knowledge Forum could provide further utility while complementing the intended purpose of the existing technology for TLLP participants and/or PLCs.

Knowledge forum® as knowledge development environment in a Community of Practice

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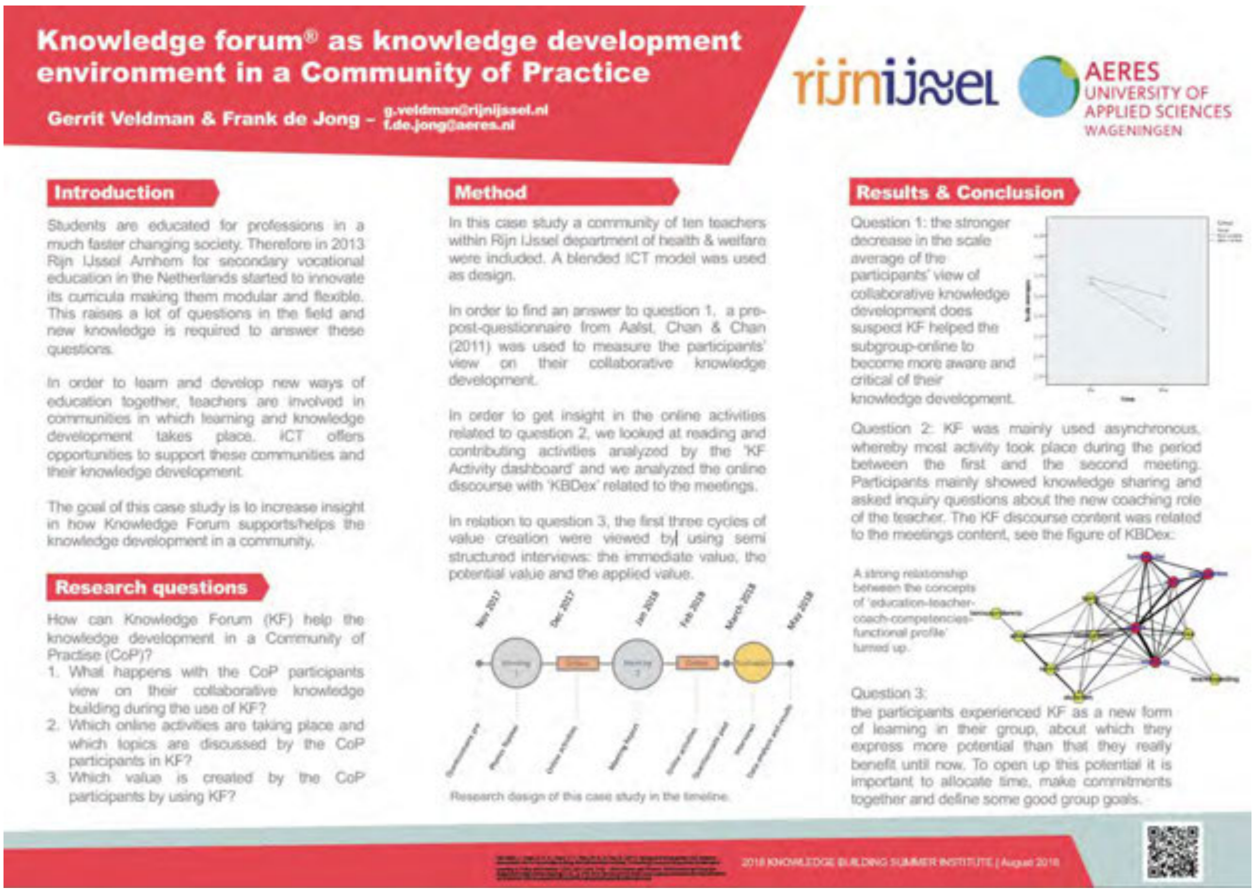

The intellectual structure of empirical Knowledge Building studies published in the selected Journals from 2006 to 2017: A co-citation network analysis

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Abstract
For researchers and educators in Knowledge Building (KB), a better understanding of the research trends in KB could be crucial. With qualitative content analyses, Wu and Wang (2016) has reviewed the empirical KB studies indexed in the Social Science Citation Index (SSCI) database from 2006 to 2015. To get more insights, the further exploration of the existing linkages among the most central and prominent recent empirical KB studies, as well as the emerging research topics and research streams in KB research, could be helpful. To this end, with co-citation network analysis, this study explored the intellectual structure of the empirical KB studies published in selected Journals from 2006 to 2017. In particular, this study aims to (a) identify the most frequently co-cited empirical KB studies, (b) visualize the intellectual structure of the core KB studies, and (c) highlight the research streams and relationships on the co-citation network of KB studies. The co-citation network analysis used in this study integrates a series of computer-based systematic analyses, including document co-citation analysis (DCA), social network analysis (SNA), and exploratory factor analysis (EFA). With the co-citation analysis, this study has found three main research streams in the co-citation network of recent empirical KB studies: *practical innovation for knowledge building*, *community knowledge assessment in knowledge building*, and *alternative knowledge building teaching strategies*. Further qualitative analyses were conducted to identify and illustrate the various characteristics of these main KB research streams, and the implications derived from this study are further discussed as well.

Extending Knowledge Building Discourses through Cross Community Collaborations

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The issue/problem

Connecting knowledge communities and databases across the world has been suggested as one of the main focuses for the future in KBSI (Scardamalia, 2017). Bringing Knowledge Building classrooms together and sustaining inquiry-based learning needs new technology and creative designs to facilitate the process over time and across spaces. New research is needed to to bridge discourses and practices across Knowledge Building communities over time more smoothly and productively.

Major goals

Drawing upon the results of the previous two years' research (Zhang & Yuan, 2018, Yuan & Zhang, 2018), the research team has been continuously developing and revising features of a new technology tool called Idea Thread Mapper (ITM), an innovative tool embedded in Knowledge Forum to further support students' collaboration both within and across communities (Chen & Zhang, 2016; Zhang, al, 2018). This research aims at promoting students' sustained knowledge creation from cross-classroom activities among Knowledge Building communities, investigating how cross-classroom interactions and collaborations take place and leveraging the understanding of students' learning.

How the research addresses the issue?

In this 6 month design-based study, students from four Grade 5 classrooms studied human body systems using ITM. Researchers conducted a multi-layer interaction design to support students' cross-classroom sharing and knowledge build-on. As students continued their own inquiry learning in their own research group, they created "Journey of Thinking" as a reflection of their knowledge (Figure 1). This "Journey of Thinking" can be further edited and then shared on the platform to be viewed by all other classrooms. A word cloud (Figure 1) visually captures and displays the most frequent keywords inside of the "Journey of Thinking". After entering the cross-community space (Figure 2), a search function helps students to quickly find all the related "Journey of Thinking" entries that contain the keyword(s). To further facilitate students' cross-community collaborations, students generated a "Super Talk" -- an overarching question for the whole 5th grade to answer: How do people grow? Students from different classrooms and different topics worked together to answer this question collaboratively. At the end of the whole learning unit, each class had a metacognitive meeting which connected "Super talk" back to the home class and triggered students' deeper discussion about the human body systems (Figure 3).

Advances

To understand the quality of students' cross-classroom collaborations via "Super Talk", researchers examined the "Super Talk" discourse with 22 students participating in the discussion from four classrooms. Students collaboratively answered the research question from Bone and Muscles, Brain and Nervous systems, Cells and Genetics, and Digestive systems. Approximately 50% of the notes are build-ons, which reflects a higher level of student collaboration and knowledge build-on. 86% of the notes show a higher level of elaborated explanations (Zhang, 2007), which shows students' efforts in producing high quality notes in the "Super Talk".

To understand how the within-classroom discourse and cross-classroom "Super Talk" interacted to support deep inquiry, content analysis (Chi, 1997) was used to analyze how the overarching topic triggered and helped students to understand the human body systems. At the end of the semester, each of the four classes held metacognitive meetings (Figure 4). Researchers selectively transcribed three metacognitive meeting videos from each class, one from the 2nd month, one from the 5th month (example from two classes illustrated in Figure 5 & 6), and one from the sixth/last month in which students discussed what they had learned from the Super Talk (example from two classes illustrated in Figure 7&8). A discourse analysis software KBDex (Oshima, 2012) was used to examine how students' discussion changed over time and the discourse characteristics that emerged from "Super Talk" cross-classroom collaborations. Students actively reflected what they read and wrote on the "Super Talk", and brought new information back to the home class discussions. This new information further triggered deeper conversation and made more connection between various groups to further understand the human body systems.

Next steps

We are conducting deeper analysis of the cross-classroom inquiry to examine the quality and pattern of students' interactions. A multilevel analysis will be used to understand how individuals' interaction patterns are associated with different classrooms' teaching strategies. Based on the findings from this research, we will update our design of "Journey of Thinking" reading and writing processes, and investigate and revise our design of "Super Talk" collaboration.

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Appendix:

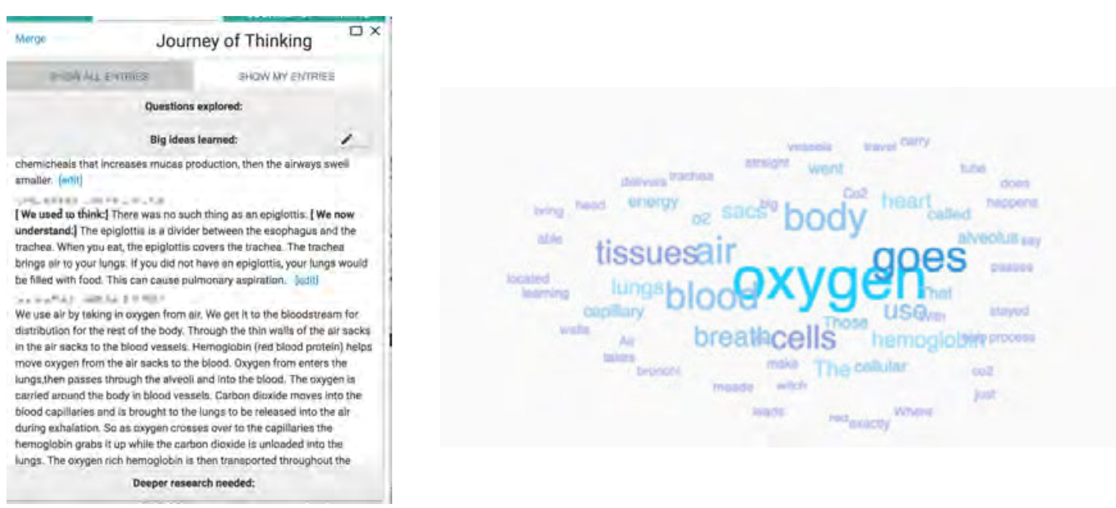


Figure 1. “Journey of Thinking” and the “word cloud” from the Lungs group

Figure 2. Cross-project Sharing Space for 4 communities in Idea Thread Mapper

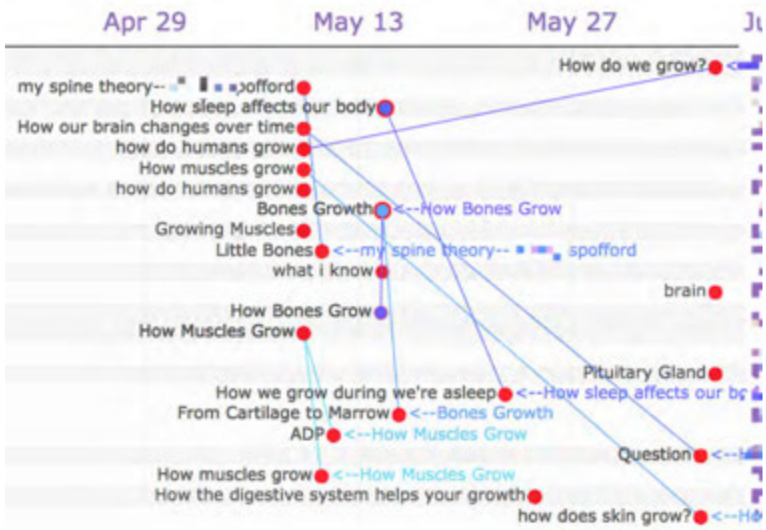


Figure 3. “Super Talk” with an overarching question “How do we grow?” in Idea Thread Mapper

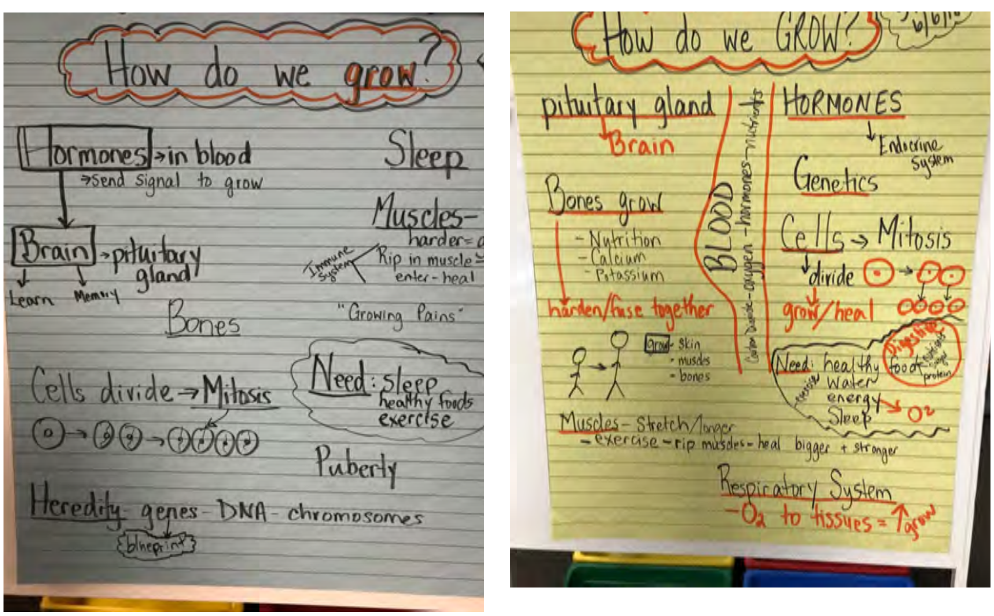
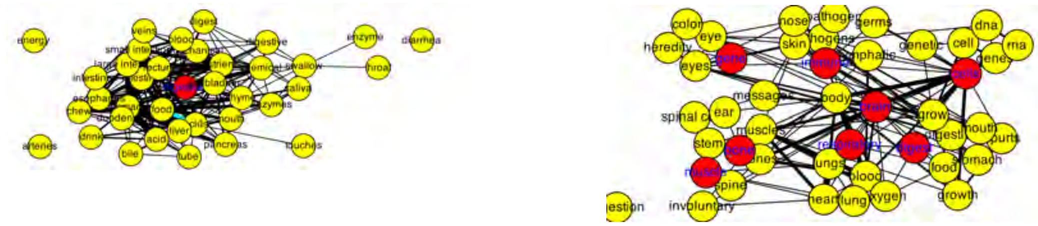
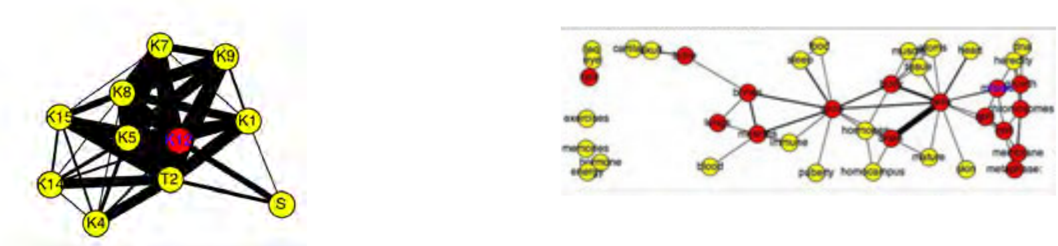


Figure 4. Class A and Class B’s charts from their last face-to-face metacognitive meetings (6th month)



<u>Figure 5.</u> Class A's topics changes from the 2nd month to the 5th Month (red represents the main systems students mentioned)

<u>Figure 6</u>. Class B's topics changes from the 2nd month to the 5th month (red represents the main systems students mentioned)



<u>Figure 7.</u> Student K12 from Class A brought in a major concept from "Super Talk" back to the home class and triggered extended connections in MM

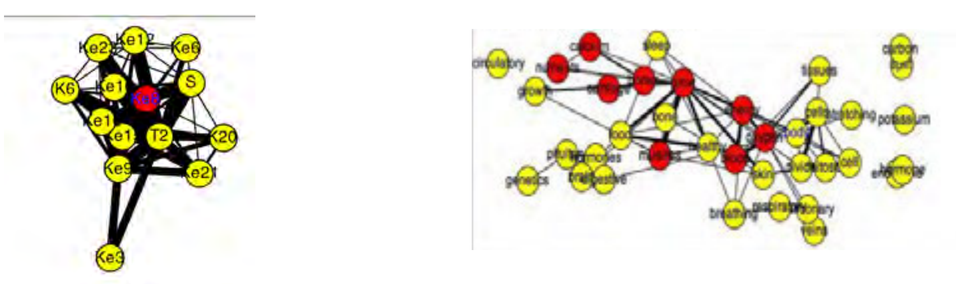


Figure 8 Student KE8 from Class B brought in major concepts from "Super Talk" back to the home class and triggered extended connections in MM.

Acknowledgments

This research was sponsored by National Science Foundation (IIS#1441479). We thank the teacher and students for their creative work enabling this research.