Building Knowledge for Public Good: Meeting New People and New Ideas in Knowledge Building's Metaspace

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Building Knowledge for Public Good: Meeting New People and New Ideas in Knowledge Building's Metaspace
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INNOVATIVE FORMAT

LONG PAPERS

From "Me" to "We": Evolving Educator Roles to Foster Collective Responsibility and Symmetric Knowledge Advancement in Schools

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Abstract: Under Ontario's Education Act Amendment (1980), special education is considered an essential service in schools to help all students reach their full potential and succeed academically. Special Education Resource Teachers (SERTs) are required to provide individualized supports for students with disabilities or special needs and play a critical role in fostering a safe and inclusive culture in schools, yet their contributions to the academic life of schools is often understated. This paper aims to explore the evolving roles and responsibilities of a Special Education Resource Teacher committed to fostering a Knowledge Building culture in three elementary schools. The teacher's design iterations over the course of three years is documented and assessed in light of students', teachers', and administrators' reflections on school climate and culture. Implications of these principles-based design iterations are discussed within the context of aligning school improvement plans to advance the vision of an inclusive knowledge society.

Introduction

The province of Ontario – one of the most diverse jurisdictions in the world – has an education system that is consistently recognized as a top-performer internationally (Mourshed et al., 2010). For example, relative to other countries who took the 2015 PISA Test, only a small difference was found between students from high- and low-income families, with little to no difference between immigrants and their native counterparts (OECD, 2018). These findings can be largely attributed to policy changes over the years that have aimed to strengthen the province's commitment to equity by leveraging diversity in schools to make society stronger and richer. For example, the Education Act was amended in 1980 to require the provision of special education services and programs for students with "behavioural, communicational, intellectual, physical or multiple exceptionalities," with the goal of providing accommodations and/or modifications for students with special needs to succeed in classrooms and narrow achievement gaps. In 2018, Ontario's Education Equity Action Plan was refined to integrate priorities of: the Equity and Inclusive Education Strategy, Poverty Reduction Strategy, and Anti-Racism Strategic Plan in alignment with the Renewed Vision for Education in Ontario (2014). More recent changes involve the inclusion of universal design principles and culturally responsive and relevant pedagogy in school and classroom planning.

In many Ontario districts, such as Halton District School Board, schools have a School Resource Team comprising administrators, school staff, parents, and professional services staff. Among the school staff, a Special Education Resource Teacher (SERT) is a teacher who has qualifications in special education programs and services. In addition to providing individualized learning techniques to students with disabilities or special needs, a SERT works with school staff to ensure that each classroom teacher has access to the necessary information and resources to ensure the meaningful inclusion of students with special needs, while maximizing opportunities for growth and development. Therefore, the SERT plays an important role in promoting equity, achievement, and well-being in schools.

In this paper, we explore the various roles a SERT can play in transforming classrooms and schools into Knowledge Building communities, a pedagogical approach that aims to instill a sense of collective responsibility for intentional learning and symmetric knowledge advancement (Scardamalia, 2002; Bereiter & Scardamalia, 2010). Guided by principles rather than procedures, the Knowledge Building framework allows educators to design customized solutions that empower students to take ownership of their learning and deepen their engagement with ideas through collaborative discourse (Chan, 2013). For example, Knowledge Building has been shown to support the academic achievement of students from low-income backgrounds (Yang et al., 2019; Hong et al., 2020), as well as students with special learning needs (Ma & Akyea, 2020). In this paper, we elaborate on exploratory and expansive processes involved in designing principle-based practices in schools. More specifically, we follow the journey of Lori Belford, a Special Education Resource Teacher in Milton, Ontario dedicated to fostering a Knowledge Building culture with staff and students. Over the course of three years, Lori engaged her administrator and staff in co-design and re-design of classroom practices that facilitated the spread of Knowledge Building in three schools. In each subsection, we provide an overview of Lori's problem of practice before describing how she

simultaneously implemented multiple principles into the culture of the school, which extended into staff meetings, classroom practices, and extracurricular activities. We conclude each subsection with excerpts of students', teachers', and administrators' reflections on how Knowledge Building has transformed their schooling experiences.

Year 1 – Classroom Teacher and Special Education Resource Teacher

Collective Responsibility, Idea Improvement, Real ideas, authentic problems

Lori was introduced to Knowledge Building at her first school, where staff shared a vision of creating a school-wide culture of caring and thinking (Noddings, 2012). By adopting a Knowledge Building approach to realize this vision, their shared purpose was to foster *collective responsibility* through the lens of *improvable ideas* toward developing and advancing community knowledge. At staff meetings, teachers and administrators would spend time examining and reflecting on *real ideas, authentic problems* across the curriculum while discussing strategies for engaging students through the use of new technologies. As the SERT, Lori was faced with the added challenge of strengthening the sense of community in the school where there were three distinct educational programs – learning disabilities, life skills, and gifted. Figure 1 shows the norms of engagement that served as the foundation for fostering a Knowledge Building culture in their school.

a) 

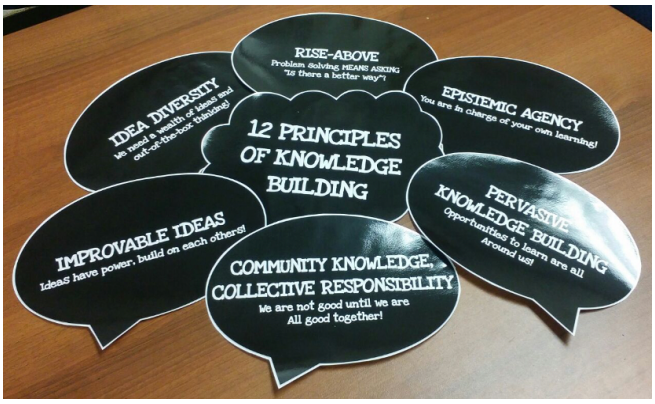
b) 

Figure 1. Norms of engagement for a) collective responsibility and b) KB principles.

One initiative that Lori started in her school was an entrepreneurial program to raise money and give back to a local charity. From its inception, Lori worked with students to develop an emergent project and timeline without forcing the project to fit within the confines of the curriculum. As the project evolved, students determined that their collective aim would be to give back to a family within the school community. Students took ownership over the project by actively setting short-term goals to sustain their learning, including writing letters to local organizations and telephoning community partners to collect funds. Once they reached their fundraising goal, students set a new goal to design a community fair to raise awareness in their local community. Beyond entrepreneurial and financial skills, this project allowed students to hone their literacy skills, including reading, writing, and oral communication. Through this initiative, Lori came to realize that student voice is the biggest resource in her school. She continued working with school staff to create a safe and inclusive community in the school by exploring different strategies to be more responsive to students' ideas, where students of all abilities feel valued and heard.

Reflections from administrators

Below are reflections from Lori's administrator about how a Knowledge Building culture provided psychological safety not only for students, but also for teachers to take risks with ideas. The "Give it a go" stance adopted by school staff has culminated into qualitative gains in student engagement and student achievement:

> This change process has been very much predicated upon building trust in relationships, where staff feel that they can "Give it a go" and their work is celebrated regardless of the results; it's characterized as an opportunity to learn and grow together… And the excitement both from staff and students, particularly around assuming collective responsibility for idea improvement has just been remarkable: The level of social and intellectual engagement in students has been unparalleled in other work that we've done. This has certainly been work that has really improved the depth of dialogue happening in classrooms, the quality of written work and oral

> communication… [The] students are owning the work, and we are really getting the sense of academic emphasis throughout the school.

Reflections from school staff

The Knowledge Building culture in staff meetings also increased a sense of collective efficacy (Derrington & Angelle, 2013), as teachers revealed their vulnerabilities, acknowledged the messiness of their work, and celebrated small incremental gains. Over the course of the year, teachers became co-learners through iterative questioning, learning with and from the students, and working together to improve the achievement of all students in the school. One teacher reflected that the staff meetings were key to *democratizing knowledge* and sharing ideas between classrooms: "As educators, the participation in the deprivatization of our practice allowed us to learn, reflect and grow together". Beyond academic emphasis, another teacher observed how Knowledge Building impacted students' well-being "because they feel like their voices are being heard and they feel safe to take risks to try something new, to work with different people".

Reflections from SERT

One of Lori's key learnings is the power of student voice in driving authentic learning and school change. Below are Lori's reflections as they relate to administrators' and teachers' reflections on how the school's Knowledge Building culture supported student well-being and academic achievement.

> Students know that they can approach anyone on staff, whether that's a teacher or administrator. They can advocate for things they believe in. For example, it could be something like, "We're not comfortable going into the washroom", and that can really spark a change in the school. We went from the notion of "I feel uncomfortable" to doing a survey within the school and updating the bathroom [based on students' ideas]… That indicates that they matter – that even one voice matters… There were three things we noticed around student achievement: student engagement, behaviour, and data. With student engagement, we noticed they are more up to engage in research and information that is authentic and meaningful to them. We noticed that the behaviours in class have improved because they are engaged in something that want to learn about. And the data suggests that our DRA [Developmental Reading Assessment] scores on fluency and comprehension have improved.

Year 2 – Teacher Librarian and SERT

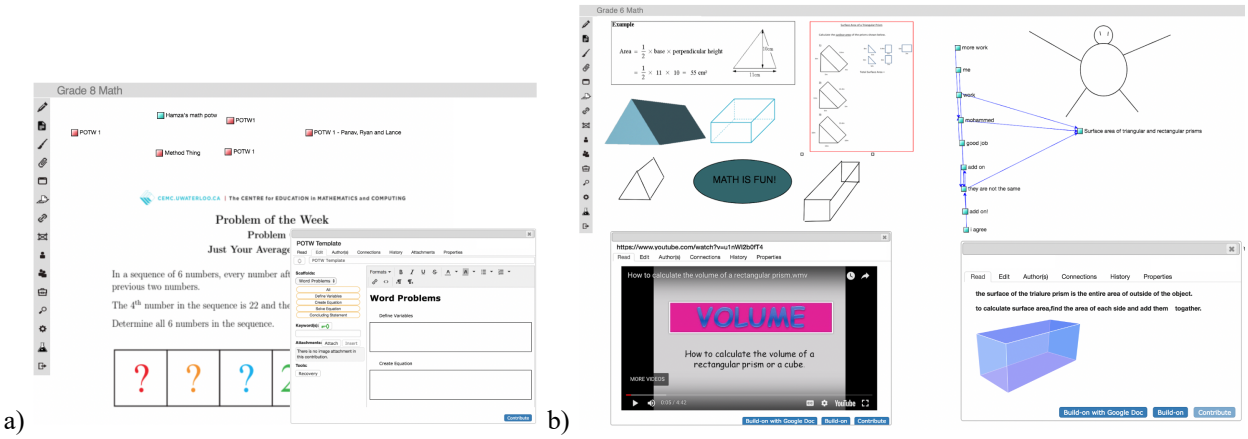
Democratizing knowledge, Knowledge Building discourse, Epistemic agency, Symmetric knowledge advancement

At her next school, Lori was the teacher librarian. Building on her insights about the power of student voice from the previous year, Lori was interested in going deeper with the principle of *epistemic agency* and worked with teachers to create equitable opportunities for students to participate in class discussions, particularly for those who were shy or struggled with anxiety. Through her involvement in the Knowledge Building Innovation Network (Ma et al., 2019), she learned about new tools and strategies in the KB Gallery (Resendes & Dobbie, 2017) and exchanged ideas with educators in different districts to refine her practices toward deeper integration of the Knowledge Building principles.

One practice that was particularly helpful in shedding light on the principle of *democratize knowledge* was the TOGA table (Milinovich & Ma, 2018). While wonder walls were conducive to making student thinking visible, Lori learned from another teacher in Hamilton how the practice of wonder walls could be improved to incorporate the principle of *Knowledge Building discourse*. By bringing this improved practice to her school, Lori noticed the direct impact on *epistemic agency*, with students taking ownership of their learning by running their own KB circles. With the support of the KB scaffolds, students found multiple entry points to participate in class discussions and felt that their voices were being heard by their peers. This shift in the students also resulted in a shift for the classroom teacher, where they became more responsive to students' needs by listening more closely to ideas that emerged from KB circles and integrating those ideas into subsequent classroom activities.

To help teachers go deeper with their classroom practices, Lori introduced Knowledge Forum (Scardamalia & Bereiter, in press) as a way to make wonder walls and TOGA tables more interactive in a digital space. Knowledge Forum served as the central space for students to build knowledge together and sustain idea improvement. In addition, Lori co-designed KB scaffolds with teachers to help create norms of engagement online that could be applied to different grade levels and curricular areas, including math, science, and social studies. They also experimented with different ways to structure the student discourse online. Figure 2a) shows a view for a Grade 8 gifted math class, where students worked with customized scaffolds to tackle a close-ended problem. Figure 2b)

shows a view for a Grade 6 math class, where students worked with notes, diagrams, drawings, and videos (i.e., authoritative sources) to solve an open-ended problem. Students enjoyed building on each other's ideas in Knowledge Forum, and teachers noticed that Knowledge Forum gave quieter students a safe space to share their ideas. Even when one student didn't get the right answer, they elicited help from their peers and declared in a note, "I'm not giving up!".



a) b)

Figure 2. Knowledge Forum views in a) Grade 8 math and b) Grade 6 math.

Although initial use of basic scaffolds felt at times a bit scripted (e.g., "I agree", "I disagree"), gradually, students began to incorporate more idea-centered scaffolds to engage in meaningful conversations with their peers (e.g.," My idea is like… because…", "I want to build on to [student's] idea"), with teachers noticing the quality of Knowledge Building discourse deepening over time. Teachers also noticed that students' discourse extended to the playground in the form of pro-social behaviours during recess, where students used the KB scaffolds to disagree with kindness and facilitate the conflict resolution process. In addition to seeing how a Knowledge Building culture pervades beyond the classroom, teachers began making their own connections between the Knowledge Building principles and Ontario's framework for global competencies (2017), which includes: 1) collaboration, 2) communication, 3) critical thinking and problem solving, 4) innovation, creativity, and entrepreneurship, 5) self-directed learning, and 6) citizenship. One teacher even decided to connect with another school to take their Knowledge Building practices in math to the next level with the global competency of digital citizenship and the Knowledge Building principle of *symmetric knowledge advancement*.

Reflections from school staff

Below are reflections from teachers about how a co-learning stance was necessary to using a Knowledge Building approach to teaching – an approach that shifted relationships between students' ideas and teachers' ideas in the classroom and resulted in dual-layer Knowledge Building occurring among teachers as much as with students (Tan et al., 2016).

> "We realized it wasn't just the students building knowledge and developing global competencies, we as educators were also building and developing our own."

> "I have become a more responsive teacher, truly listening to my students, providing provocations and supports at the right moments and being open minded to the direction they take the learning."

Reflections from students

Below are reflections from students in different grades, as it relates to various Knowledge Building principles, suggesting a school-wide shift toward a Knowledge Building culture:

> *Democratizing knowledge*: "We got to hear people's ideas and see what they really think and more."

Idea improvement: "I guess it's okay working with people because they can kind of grab an idea and make it into something better."

Idea diversity: "My topic was controversial, and I learned that I was really biased when I started the project. However, I realize I need to consider other points of view. I also need to not be biased when researching by only looking for research that supports my opinion. I need to look for reliable research from other perspectives too. That's my next step."

Symmetric knowledge advancement: "Maybe in the future we should share with another class because it was fun, and it might help them with their problem solving skills."

Reflections from SERT

One of Lori's key learnings is that being more responsive to students also involves letting go of teacher control and releasing more agency to students (Toth & Ma, 2018) – the dynamics worked in parallel and had positive unintended consequences on student mental health and well-being, such as improving peer connections and self-confidence. Below are Lori's reflections:

> At first, it was hard for me to let go of the control, and I wasn't really sure what my role was if I was not always the one always imparting the knowledge. Through the support and guidance of my admin we were given an opportunity to further engage in our work as educators using the KB principle of *Improvable ideas*. So, I started to guide students towards their own learning goals using questioning and encouraged them to form groupings based on interests... Knowledge Building has allowed me to learn alongside my students and create classroom environments where authentic learning challenges are embraced. In any school I work in, my starting point is always trying to shift from a "ME to WE" philosophy so that students feel that "WE" are better when we work together and collectively. That "WE" would all be responsible for gathering and sharing our knowledge in a meaningful way. That "WE" should count on and appreciate others' talents and skills, and that everyone can and should contribute to our learning. Lastly, that "WE" have the power to make a change in our thinking and share our knowledge using KB scaffolds. It is so refreshing to reflect and share how far we have come, but my journey is not over because in my current role as a teacher librarian and SERT, my goal has been to promote KB principles through the use of technology. This has definitely been a shift for me as I continue to learn and grow alongside my students on this KB journey.

Year 3 – ESL and Planning Teacher

Democratizing knowledge, Epistemic agency, Idea Improvement, Community knowledge

This year, Lori is an ESL and planning teacher at a new school and her hope is to work closely with administrators and teachers to algin Knowledge Building with their school improvement plan. Lori is leading professional development meetings with staff to address shared problems of practice together. This idea came about after their initial staff meeting, where she presented the idea of embedding KB into daily school practices. After this discussion, new questions emerged within the context of school recovery during the pandemic, including "What *real, authentic problems* are our students in our school community facing?", "How can we continue to make our classrooms more student-centered using the 12 KB principles?", and "Is my KB classroom culturally responsive? Is the pedagogy relevant and impactful for my students?". Over the course of this year, Lori will continue networking with staff and students to foster a Knowledge Building culture in her new school.

Recall that Lori was first introduced to Knowledge Building through the principles of *collective responsibility* and *idea improvement*. Through her work as teacher-librarian co-designing practices with teachers, she came to see the value of additional principles such as *democratizing knowledge* and *epistemic agency*. From a design perspective, it is interesting to note that as she starts the school year with staff, she is integrating multiple principles with varying degrees of difficulty to deepen teacher reflections while they lay the foundations of a Knowledge Building culture at their school. Likewise, in past work, it was noted that teachers who engaged with principles that departed from traditional modes of schooling were able to go deeper with their Knowledge Building practices (Horner & Ma, 2020; Milinovich & Ma, 2018). Over the course of the last few years, Lori has been building up the *epistemic agency* of her students by empowering them to advocate for themselves, drive their own

learning, and spread their learning with their peers. Her efforts have in turn built up her own sense of *epistemic agency*, as she reflects: "I realized that changing my teaching practice was only one small step in the process, and that leveraging the 'third teacher'[the environment] is a necessary next step to redefining our school culture".

Discussion

A Knowledge Building culture is fundamentally rooted in community well-being with the belief that "We're not good until we're all good!" (Resendes & Dobbie, 2017). As an educational approach, it is well-aligned with the principles of acceptance and inclusion in Ontario's K-12 schools, with all "students see[ing] themselves reflected in their curriculum, their physical surroundings, and the broader environment, in which diversity is honoured and all individuals are respected" (Ontario Ministry of Education, 2017). The global pandemic has exposed flaws in many education systems, including the lack of preparedness of schools to respond to crises and amplified disparities between different communities, in some cases, preventing access to essential services such as special education programming. Whether the challenge of school recovery is framed as learning loss or decline in mental health (Dorn et al., 2020), student achievement cannot be improved without improving student well-being – the two go hand in hand according to the whole child approach to schooling (Darling-Hammond & Cook-Harvey, 2018). Now, more than ever, students, teachers, administrators, and parents must assume *collective responsibility* and *rise above* individual differences to craft a new and improved normal in schools – one that prioritizes mental health, psychological safety, racial equity, and community well-being.

Lastly, we propose that Special Education Resource Teachers play a unique role in crafting this new normal. It is interesting to note that the role of the SERT in school change and school improvement is often underrepresented in policy documents that are not related to special education (see for example, Institute for Education Leadership, 2013). However, this paper aims to illuminate the critical role of the SERT in transforming the learning culture in schools in ways that simultaneously advance equity, achievement, and well-being. According to Ontario's Education Leadership Framework (IEL, 2013), a SERT is well-positioned to be a school leader – a teacher like Lori has been "pivotal to the development of excellent teaching, excellent schools and ultimately, enhanced student achievement and well-being" across three different schools in the province. As Lori suggests, not only do teachers need to work with one another, but also the "third teacher" (the environment) to intentionally design school spaces that foster community, relationships, and trust. More work is needed to understand how SERTs, teacher librarians, ESL teachers, and planning teachers can lead school change during the pandemic. It is our hope that this paper can bring new insights to the theme of "a rising Knowledge Building tide lifts all boats" in the global Knowledge Building design experiment.

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Use Distance Shortening Strategies to Enhance Opportunistic Collaboration in Knowledge-building Environment

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Abstract: Carrying out opportunistic collaboration is an important condition for Knowledge Building community formation and in other knowledge creation organizations. At present, fixed-group collaboration is still widely conducted in practice, which, to some extent, hinders the development of knowledge creation activities. This design-based research employed "the distance shortening strategies", namely shortening students' physical distance and mental distance to support their opportunistic collaboration. Participants were 24 masters students who learned the Learning Sciences in Knowledge Building community during 12 weeks, with online and offline activities. Data include: (1) records of online activities; (2) video clips of offline activities; (3) content of online notes. Social network analysis, video analysis, content analysis and interview analysis were applied accordingly. Findings revealed that "the distance shortening strategies" were helpful in engaging students in opportunistic collaboration. To help students engage in opportunistic collaboration, teachers should pay attention to providing them a free and flexible learning environment and make students understand the connections among different notes.

Introduction

It is widely acknowledged that ~~the~~ opportunistic collaboration, with flexible and changeable organizational structure as well as social configuration are essential to support effective interaction and make creative knowledge work happen (Amar,2002; Engeström,2008; Sawyer,2003; Chatzkel,2003). As an innovative way of collaboration, opportunistic collaboration is generally found in research, science, and business communities where knowledge creation is of frequent occurrence (Gloor, 2006; Naeve, 2010). In poster sessions and workshop, for instance, people collaborate under their own volition, based on emergent goals; Wikipedia, has been developed and continued to update through people who collaborate on diversified ideas without forming a specific group. The well-known Homebrew Computer Club in Silicon Valley that has made huge innovation success in science and technology was first started with a group of people who were interested in computers gathering together regularly and exchanging ideas as well as collaborating freely (Defillippi,2006). As Chatzkel (2003) asserted, people need to feel free to move about in their organization, to group and regroup in different organization as needed…" To this end, opportunistic collaboration is emerging from knowledge organizations, among knowledge workers, which helps to promote ~~the~~ knowledge innovation.

Under this circumstance, traditional fixed-group collaboration is less and less able to respond properly to many of the challenges that face us today when the demand for knowledge innovation is ever-increasing. Changing traditional collaboration into ~~a~~ more idea-oriented, unplanned and opportunistic ways of working is the solution for the knowledge society (Handy,1989; Gorelick et al, 2004), where being able to have opportunistic collaboration with peers is of great importance (Matsuura, 2005; Hong, 2011). As for students, they are supposed to experience opportunistic collaboration in order to meet the challenges and needs of the future. It is also essential to educational practice, especially to Knowledge Building, defined as "the production and continual improvement of ideas of value to a community" (Scardamalia & Bereiter, 2003), which tries to help students develop an idea-centered view of collaboration, also highlights the potential of opportunistic collaboration. Studies show that having opportunistic collaboration in Knowledge Building can lead to a high level of collective responsibility, more pervasive, flexible, distributed collaboration, and greater dynamic diffusion of information and knowledge advances (Zhang, Scardamalia, Reeve & Messina, 2009; Siqin, Aalst & Chu, 2015), as opposed to what happens in fixed-group collaboration.

However, neither teaching practice nor research about opportunistic collaboration in Knowledge Building is enough. A predominant view of collaborative learning is that students are assigned to a group and asked to finish a whole task by doing parts of it. Thus, as Knowledge Building is proceeded in class, most students who do not have experience of Knowledge Building, tend to only read notes in the views of their own groups on Knowledge Forum or discuss within a specific fixed group as their responsibilities. Even though some KB teachers are aware of the importance of opportunistic collaboration, they have no ideas on how to foster students engaging in opportunistic collaboration. Moreover, current research about opportunistic collaboration in Knowledge Building are virtually

result-oriented, which focus on and verify the advantages and final results of opportunistic collaboration (Zhang et al, 2009; Siqin et al, 2013; Siqin et al, 2015). Research~~es~~ about the process on how to help students form opportunistic collaboration are rare. Zhang's team~~work~~ tried to figure out how students initiate and develop opportunistic collaboration over time in a fifth-grade science Knowledge Building community using qualitative research method (Tian, Zhang, 2017); They also investigated the Idea Thread Mapper as an effective tool to support students' opportunistic collaboration (Zhang, Tao, Chen, et al, 2018), which is productive and necessary. However, relatively less attention is being paid to the teaching strategies on promoting and helping students engage in opportunistic collaboration. Besides, how does ~~the~~ opportunistic collaboration happen? How do students who are unfamiliar with Knowledge Building start opportunistic collaboration is an avenue for future research.

Therefore, in order to fill these research gaps, we considered the common phenomenon of fixed-group collaboration and tried the "distance shortening strategies" to help students get rid of the group boundaries not only in physical but also in mental and engage them in opportunistic collaboration. The "distance shortening strategies" is an attempt to shorten students' physical distance by changing their fixed desks and chairs in class. While shortening their idea distance in the Knowledge Building community means making students further understand their connections among ideas. This research aims to answer the following questions:

(1) Whether the "distance shortening strategies" help students be better opportunistic collaborators?
(2) How does the pedagogical intervention on shortening students' physical distance and shortening their idea distance help them collaborate with each other and improve their ideas respectively?

Methodology

Research Context and Subjects

The setting for the research was a university in Nanjing, China. Twenty-four masters students majored in Educational Technology in grade one at the average age of twenty-three, an experienced professor who has immersed himself in Knowledge Building for several years, and one researcher participated in this research. All students were new to Knowledge Building and Knowledge Forum. They have been used to traditional lecture-style teaching and fixed-group collaboration but have never experienced innovation teaching aiming at knowledge creation. The curriculum is Learning Sciences, using the Cambridge Handbook of Learning Science as reference. The aims of the curriculum are making students understand the key theories, methods of Learning Sciences and making them be able to design their teaching. In the meantime, students are supposed to have the abilities to think independently and be positive in participating in inquiries. They also need to have the consciousness to collaborate with others freely and positively and enhance their ability to engage in opportunistic collaboration. The whole teaching practicum lasted for one semester, which is totally 3 months with 36 hours, 12 face-to-face activities and online activities. Students need to be logged into Knowledge Forum to input their ideas and notes in order to continue and deepen inquiries.

Research Design

This research employs design-based research (DBR) (Brown, 1992). As an emerging research methodology in the field of Learning Sciences, DBR use carefully designed interventions and iteratively test and redesign to solve the educational problem (Hong, Lin & Chai et al, 2019). This research intends to determine effective pedagogical interventions to help students engage in opportunistic collaboration and adapt to a culture of innovative collaboration, DBR appears to be a reasonable and relevant method.

As for the overall pedagogical and research design in the whole semester, this research first tried to help all students put forward their problems and ideas that related to the Learning Sciences. After that, numbers of group topics emerged from students' problems and ideas. Then this research employed several iteration cycles to make the opportunistic collaboration happen and transform the group knowledge into community knowledge, namely, most of the students in the class community can investigate and understand the details about different topics. The iteration cycle can be divided into three parts: (1) students get to know the theories about Learning Sciences that related to their problems and ideas; (2) Design practical courses using the theoretical foundation; (3) Knowledge Building discussion and reflection is throughout the whole process (see Figure 1).

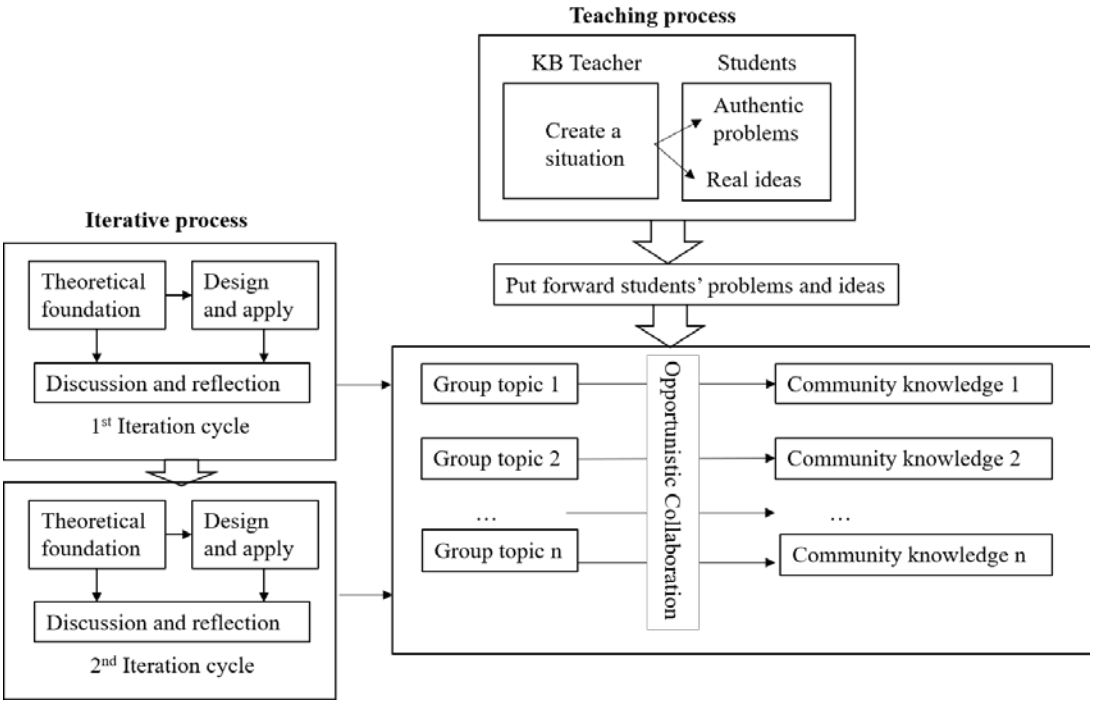


Figure 1. The research design using DBR with several iteration cycle.

Data Analysis

Opportunistic collaboration is way of collaborating that encourages innovation and creativity. In this research, active interaction and KF notes' quality are two important indicators to measure whether students engage in high quality opportunistic collaboration. Moreover, considering the teaching environment is mixed with online platform and offline activities, this research collected both the online and offline data. The online data is mainly from the Knowledge Forum, where students post notes and build on with each other. ~~Thus,~~ students' interaction and the content of notes were collected and saved every week. The offline data were video recordings of the class every week, which can record students' moving and distribution which also indicate the interaction level.

To answer the research questions, we examined the effects of students' opportunistic collaboration in each iteration to make sure the emergent pedagogical approaches are effective. In other words, students' online and offline interactions and their ideas' quality were measured. For students' interaction, online and offline Social Network Analysis (SNA) was used. To be more specific, we used density analysis to measure whether students were willing to collaborate; and we used clique analysis to measure whether students can collaborate freely and flexibly. For students' idea quality, we used content analysis. Table 1 shows the coding scheme. As for reliability, two researchers coded students' notes on KF. As a result, the inter-coder reliability was computed to be 0.86. To sum up, the specific data and analysis is presented below (see table 2).

Table 1: Coding scheme for the quality of students' ideas

Dimension	Description	Rating
The depth of questioning	Questions on definitions and simple clarification	1
	Questions asking for factual, topical and general information	2
	Questions identifying specific gaps and asking for open-ended responses and different viewpoints	3
	Explanation-based questions—Focus on problems not topics; identifies sources of inconsistencies; generates conjectures and possible explanations	4
The depth of explanation	Repeat or simple restate a fact or a statement that has been made	1
	Give factual information and general description; responses are usually centered on facts and topics; cut and paste; is used rather than making own interpretations	2
	Give responses and make inferences supported with some relevant information	3

	Make assertions supported with explanation, evidence and relevant examples	4
	Refocus discussion or highlight key conceptual issues for further inquiry; bring out other aspects of issues for discussion	5
	Recognize high points in discourse; metacognitive, show personal reflection	6
	Synthesize different points of views and make a rise-above summary	7

Table 2: Data and analysis to answer research question

	Data	Analysis
RQ. How does the pedagogical intervention on shortening students' physical distance and shortening their idea distance help them collaborate with each other and improve their ideas respectively?	・Notes' content and their relation on KF ・Video recordings of the class every week	・Social Network Analysis, including density, clique analysis. ・Content analysis. ・Video analysis

Iteration Process

The First Iteration: Shorten Students' Physical Distance

Referencing the other research and previous observation, it is a common phenomenon that numbers of students tend to having fixed-group collaboration seldom leave their seats even though teacher has asked them to do so. In order to encourage students to leave their seats and start to collaborate with different people, we first tried to provide them a safe and free learning space that fits well into opportunistic collaboration. Therefore, in the first iteration, all the desks and chairs were changed from fixed position into flexible position, specifically, the desks and chairs were equipped with scroll wheel so that students can easily combine different tables as they wish and collaborate freely.

After changing the learning environment, we found that only a few students participated in free discussion. Most of the students still gathered together based on their old groups. They did not care about others' ideas, which indicated that this intervention did not help a lot. The researcher made a guess that putting desks in the classroom might be the barrier for students to move around and mislead the students to group first. Thus, in the next week, the researcher and the teacher moved out all the desks and only the chairs were preserved, which aimed at breaking the barriers and boundaries of fixed groups (see figure 2).

Figure 2. The situation after moving out all the desks

Moreover, a Knowledge Building Circle, a live discussion held in a circle was used to make the learning environment free and enlarge the scope of interaction. Students can hear more from others and the connection among each other would be much closer.

After the first iteration, the researcher carefully observed students' online and offline interaction. It was obvious that after the desks were moved out, most of the students left their fixed position and notice the topics and discussion in the whole class, the offline intensity was quite high, which indicated that students gradually engaged in opportunistic collaboration. Although the approach to have a free and flexible learning environment increased the chances of offline opportunistic collaboration, the online interaction still remained shallow. There were a lot of related notes that should have connections to generate more discussions and build-ons, but students were not aware of those connections and missed the chances for opportunistic collaboration, making the online intensity low. For

instance, one student mentioned the pros of Learning Analytics that ~~it~~ could be process evaluation and summative evaluation; Some other students while mentioning the cons of Learning Analytics noted that it paid much attention to behavior analysis, which was not enough. Two notes talked about the advantages and disadvantages of Learning Analytics, which should have a thorough discussion, however, there were no connections between these two notes. It was found that there were numbers of isolated notes on KF, which meant that students' online opportunistic collaboration was not enough. There were still considerable notes had not spread in the class.

The pedagogical intervention in the first iteration focused on the environmental building of the offline learning space and tried to gradually change the fixed-group collaboration into a more flexible collaboration in which students can move around in the class more freely. The attempts to engage students in offline opportunistic collaboration worked, while engaging students in online opportunistic collaboration and make students have deep opportunistic collaboration still need more teaching strategies. Therefore, in the next iteration, the pedagogical intervention would be related to the connection of notes, trying to make students aware they should participate in more opportunistic collaboration.

The Second Iteration: Shorten Students' Ideas' Distance

The second iteration mainly focused on engaging students in ~~the~~ deep opportunistic collaboration and ~~having~~ wide online and offline interaction. Therefore, the researcher tried to use the KBDeX to help students understand the relationship between different notes. To be more specific, KBDeX can automatically generate keyword maps and students' interaction maps. In the keyword map, students can get to know the knowledge structure of the whole class; while in the interaction maps, students would know who share the same keywords with them (see figure 3A and 3B).

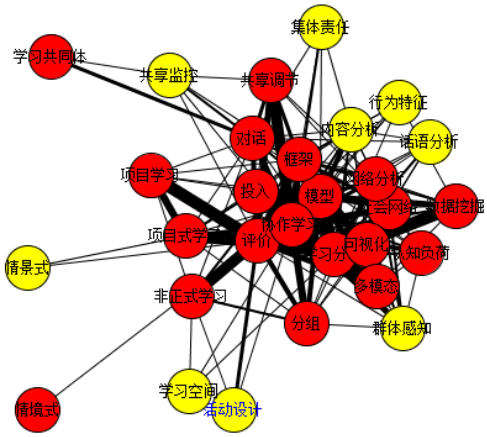


Figure 3A. Knowledge structure of the whole class

Figure 3B. Interaction maps

Additionally, we simulated several academic poster sessions for students to make them introduce their inquiry procedure. Each student was asked to take a marker and post-it notes with them and participated in different groups' inquiry projects as well as leaving some notes on their posters (see figure 4A and 4B).

Figure 4A. Students stimulating the academic poster session

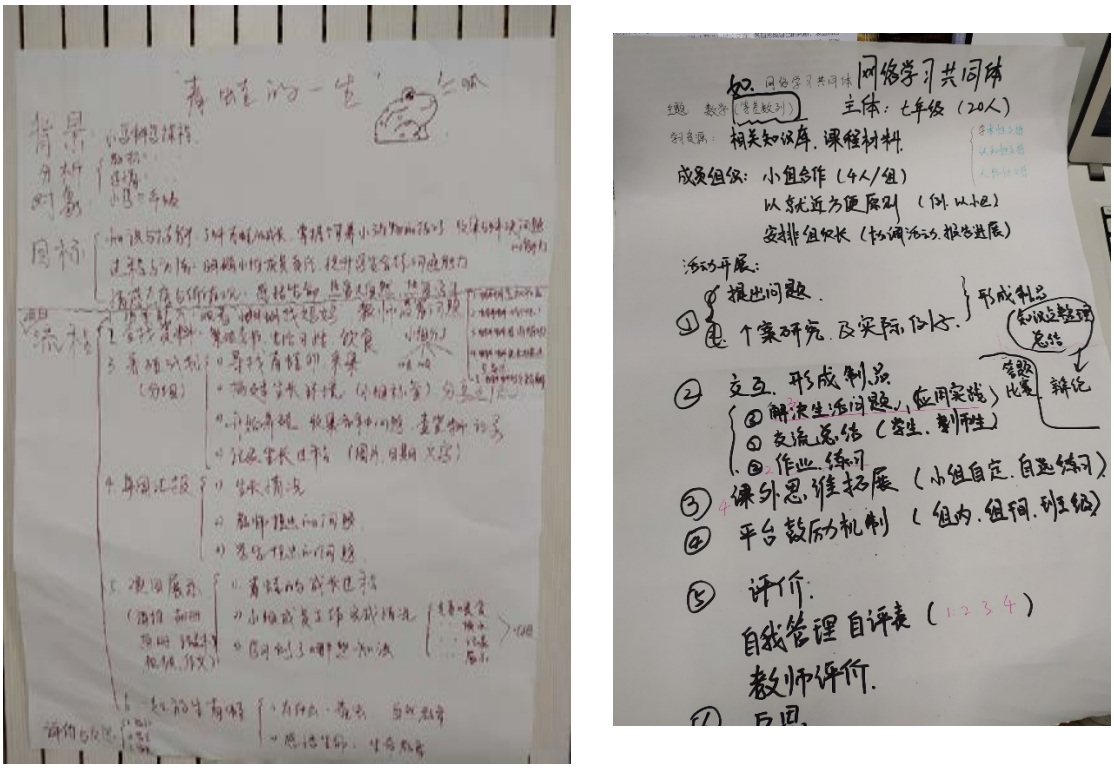


Figure 4B. Students' poster

In the later class talk, the teacher observed that students' ideas ~~were~~ developed quickly. The notes connection on KF had increased. In the offline activities, students started to realize the relation among their ideas. For instance,

Student A: These five points should be considered to design reasonable strategies in order to improve the efficiency of informal learning.

Student B: What do you think about these five points? I remember that C has his opinion in the influencing factors toward informal learning, maybe you should compare your ideas with C's opinion.

Student A: Exactly. Then I will find a better way to design my teaching strategies.

These two rounds *of* iteration have witnessed the constant change and development of opportunistic collaboration, which indicated that students have the potential to have deep level of opportunistic collaboration.

Results

After 12 weeks of investigating and data collecting, several findings emerged based on video analysis, SNA, content analysis and some qualitative analysis.

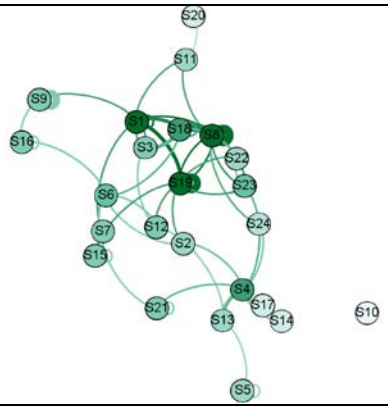
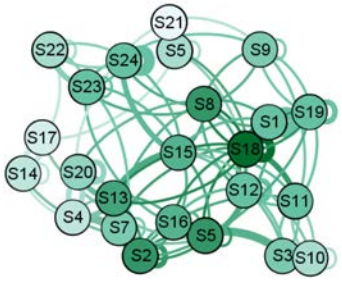
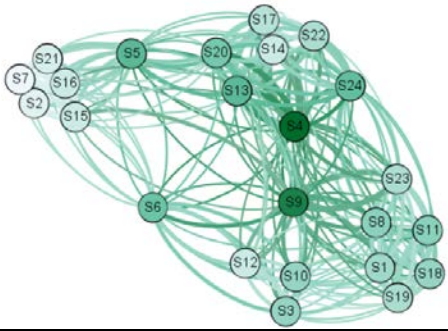
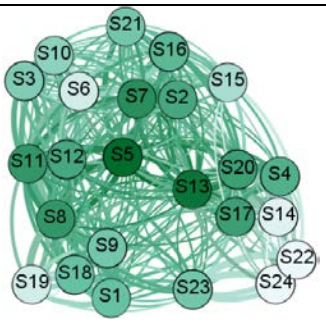
Constant Changes in Students' Initiatives

In two rounds of iteration, students' online and offline interaction ~~has~~ changed a lot. We examined students' moving in the class and their interaction density every week to determine how they have changed. For comparison of students' moving in two rounds of iteration, we use the number of students' moving divided by the duration to eliminate the interference of the duration in each iteration cycle. Then we conducted a paired-sample t-test to compare students' moving between the first and second. The result indicated that the average number of moving per unit time in the second iteration (M=.085843) is significantly higher than the average number of moving per unit time in the first iteration (M=.014163), ($t=-9.846$, $df=23$, $P=.000<.05$), which indicated that the barriers and boundaries for students to have opportunistic collaboration had gradually move out.

The researcher collected students' online and offline interaction matrix from the KF and video records respectively. After that the interaction data was imported into Gephi, then the intensity was

calculated as below (see table 4). It could be seen that the offline structure was gradually tighter and the density was increased step by step. The online structure and density had the same trend as the offline structure and density, leading us to infer that that students had the initiative–to participate in ~~the~~ opportunistic collaboration.

Table 4: Interaction structure and density

	The first iteation	The second iteration
Online interaction structure		
Density	0.101	0.205
Offline interaction structure		
Density	0.464	0.582

Flexible Grouping Situation

In order to illustrate whether students have changed fixed-group collaboration into ~~the~~ opportunistic collaboration ~~featured~~ with flexible grouping, the researcher tried clique analysis based on K-plex and set the K value = 1; Minimum set size = 3. Table 5 presented students' grouping situation in the first iteration and Table 6 presented students' grouping situation in the second situation. The results turned out that students were able to collaborate freely and flexibly especially in the second iteration, which can be inferred that the students were accustomed to opportunistic collaboration gradually. Moreover, it was found that there were some of the fixed groups, for example, the offline group 3 in the first iteration was made up with S1, S4, S8, S9, S11, S18, S23, S24, while the offline group 17 was made up with S1, S5, S8, S9, S11, S12, S18, S19. The overlap members were emerged, which indicate that students start to have a deeper and targeted collaboration with exact members.

Table 5: Students' grouping situation in the first iteration

	Grouping situation	parameters
Online interaction	Group1: S1 S3 S18 Group2: S1 S8 S11 Group3: S1 S8 S18 Group4: S1 S8 S19 Group5: S8 S19 S23 Group6: S19 S22 S23	K Value=1; Minimum Set Size=3
Offline interaction	Group1: S1 S3 S4 S8 S9 S10 S11 S18 S19 Group2: S1 S4 S8 S9 S11 S18 S19 S23 Group3: S1 S4 S8 S9 S11 S18 S23 S24 …… Group14: S4 S9 S11 S13 S23 S24 Group15: S4 S9 S13 S22 S23 S24 Group16: S5 S6 S7 S15 S16 S20 S21 Group17: S5 S6 S13 S16 S20 S21	

Table 6: Students' grouping situation in the second iteration

	Group situation		Parameters
Online interaction	Group1: S1 S6 S15 Group2: S1 S6 S18 Group3: S1 S8 S15 Group4: S1 S8 S18 Group5: S1 S18 S19	Group27: S11 S12 S18 Group28: S11 S18 S19 Group29: S13 S15 S16 Group30: S13 S16 S18 Group31: S15 S16 S23 Group32: S22 S23 S24	K Value=1; Minimum Set Size=3
Offline interaction	Group1: S1 S2 S4 S5 S13 S17 S20 Group2: S1 S2 S4 S5 S17 S18 S20 Group3: S1 S2 S5 S8 S9 S11 S18 Group4: S1 S2 S5 S8 S9 S13 S17 Group5: S1 S2 S5 S8 S9 S17 S18 …… Group17: S1 S5 S8 S9 S11 S12 S18 S19 Group18: S1 S5 S8 S9 S11 S18 S19 S23 …… Group81: S7 S9 S13 S14 S17 S20 Group82: S7 S9 S13 S14 S17 S23 Group83: S7 S9 S14 S17 S18 S20 Group84: S7 S9 S14 S17 S18 S23 Group85: S7 S10 S14 S16 S17 S20 Group86: S7 S15 S22 S23 S24		

Depth of Students' ideas were gradually Deepen

In order to verify whether students' leaning and inquiry quality has been improved, the content analysis was conducted. After that, a paired-sample t-test was applied. The results were as follows (Table 7):

Table 7. The inquiry quality comparison between the first and second iteration

	M	N	SD	t-value	Sig.
Depth of questioning					
#in the first iteration	2.9113	24	.85752	-2.765	.011
#in the second iteration	3.4663	24	.59659		
Depth of explanation					

#in the first iteration	3.3754	24	.76361	-3.953	.001
#in the second iteration	4.3146	24	.95370		

The results showed that the depth of questioning was improved gradually (M_1 = 2.9113; M_2 = 3.4663), and there was a statistically significant difference between first and second iteration(t=-2.765, P=0.011<0.05). As for the depth of explanation, the depth of explanation in the second iteration was much higher than the depth of explanation in the first iteration (M_1 =3.3754; M_2 = 4.3146), and there was a statistically significant difference between first and second iteration (t=-3.953, df=23, P=0.001<0.05).

Conclusions

Promoting students' Opportunistic Collaboration is a systematic and complex process. To change student' fixed-group collaboration habits by designing an adequate environment that is flexible and adaptable to Opportunistic Collaboration is the very first step. Secondly, it is reasonable to reinforce students' idea diffusion and interaction by enhancing the relevance of ideas and making students' ideas flow, as well as increasing idea diversity and richness. The pedagogical approaches proposed in this research will provide a fundamental guidance for carrying out collaborative activities and training knowledge workers in Knowledge Building Communities and other knowledge creation organizations.

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Epistemic Cognition: Collaboration Among two Knowledge Building Teacher's Classrooms: Continuum across Idea Trajectories & Next Steps

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Abstract: Epistemic cognition is an essential method for students to address and recognize complex issues with Knowledge Building. This paper will examine how two teachers combined their subject matter classes to cross-curricular Knowledge Build with the same cohort of students. The research demonstrates how students co-constructed ideas across curriculum topics Biology and Reasoning, utilizing ideas in both courses to understand and approach a new final epistemic task. This exploratory research presents discourse usage, using KBDEX & word clouds to compare to the expert corpus, as well as understating examples of student reasoning analyzed to demonstrate how ideas trajectories evolved over the course and for the final project contributions. This instance was the student's first-time utilizing Knowledge Building pedagogy & Knowledge Forum. We found that student's surpassed expectations and demonstrated several examples of relational reasoning and epistemic ideals. This research opens new avenues of research between teachers to collaborate to achieve more learning across trajectories instead of siloed courses.

Introduction

Students cannot solve real-world problems without examining the argument or presented issue through multiple viewpoints. There are connections among various topics that have more widespread factors at play. When a classroom focuses on a problem, traditionally, they take on a specific goal or aspect and learn about it. However, when you start researching, you can begin to see an interconnectedness amongst ideas. For example, if we begin examining the Sustainable Development Goals (UN General Assembly, 2015), and if we are to precisely examine the goal to eradicate world hunger, we can begin to see overlap with other goals, such as Education or Climate change. There are debilitating effects that lead to factors in assessing to understand the solution. The first steps to comprehend starting discussions on innovations to understand possible solutions or innovations are key to idea improvement. Students usually lack how to approach these challenges and when they are to apply that knowledge. How should they understand that they can access an abundance of information, but how can they rationalize and reason to make sound claims that lead to new ideas? Students can work productively with these ideas and see connections across complex ideas is to utilize reasoning and heuristics to rationalize, reason, and produce robust rationales. These can be seen as transferable skills for future learning and to make sense of varied learning contexts. Reasoning can be defined as "methods such as cause and effect to demonstrate logical thinking, as well as presenting evidence that either refutes or proves an argument. (Changwong et al. 2018, p.41). To reason allows for students to examine an argument by not just providing an opinion but rationalize, support, and find relevant context to demonstrate why their critique or ideas are of merit and have some rationale to strengthen its merit. Related to reasoning is the concept of "relational reasoning" (Bunge et Leib 2020). This is defined as "the cognitive ability to compare or integrate the relations among disparate pieces of information" (p.167). Relational reasoning is seen as a predictor of scholastic achievement and other related important life outcomes. (Goldwater & Schalk 2016).

Reasoning within argumentation allows for students to enact epistemic ideals (Barzilai et Chinn, 2017). Epistemic ideals enable students to evaluate a claim's accuracy or inform them of a well-justified argument by evaluating the process and how these epistemic aims have been achieved. As per Barzilai & Chinn (2017), "Epistemic education assumes that learners have beliefs, understandings, and values regarding knowledge and knowing and that these should be acknowledged and addressed. (p.354.) The purpose of having students take part in epistemic education is to change as a learner their epistemic position to a more advanced position" (p. 356). Epistemic Education aligns perfectly with Knowledge Building Pedagogy (Scardamalia & Bereiter 2006) as both have end goals that strive for idea improvement and the advancement of knowledge work. Knowledge Building as a theoretical framework extends the concept to promote epistemic education in a collaborative form. "The state of knowledge in the classroom is an emergent distributed phenomenon that cannot be found in any one student's mind" (Scardamalia & Bereiter 2014) (p. 399).

Through the formulation of accurate judgments, the evaluation of arguments and being able to do so across varied situations and contribute to the Knowledge Building community metacognitively. Students also need to, at times, spend more time gathering essential know-how knowledge to innovate a novel idea, especially with the more complex final task presented to them. As a part of this research, we wanted to examine the role of Epistemic Education within the realm of Systems Thinking. (Kim & Senge 1994). They define systems thinking as a method to understand the system we are engaged in as parts to be analyzed. Yet, they interact and intersect with each other to produce overall outcomes within its own very complex system. The importance of reasoning resonated with the two teachers within this study. The two teachers wanted to tackle the importance of cross-curricular connections, respectively, with the course work and demonstrate to students that reasoning will expand their learning to formulate better rationales behind their theories. Inadvertently, the teachers wanted to first-hand provide the idea of *Systems Thinking (Arnold et. Wade 2015)* because they know that their students will continually encounter complex problems beyond their schooling years. With infinite information at their disposal, students need to make sense of the world but need to make strong arguments – an issue they believed their students did not excel in strongly prior to these courses.

Both courses were for high school students in grade eleven. Two teachers shared the same cohort of students. Each classroom had its own Knowledge Forum community to do their work in building their fundamental knowledge within the respective topics: reasoning and Biology. This was the first experience for students with Knowledge Building pedagogy; however, both teachers have extensive experience in Knowledge Building. By going across classrooms, the idea was that students develop coherence across two subjects and be able to apply their knowledge to their final white paper project -that encompasses ideas from both courses.

These two teachers enacted Knowledge Building pedagogy within their classes - but because they shared the same cohort of students understood the fundamental ideals that Knowledge Building does not just end once the class is completed. The two teachers decided that their subject matter was complimentary and would demonstrate that because Knowledge Building does not just stop after one hour of the dedicated instructional timeline of the day. In the ideal school, all classes or teacher groups would engage in Knowledge Building and reference one another's works so that students can see connections – but that takes time and planning and can be a challenge. This study is a first step at looking at exploratory possibilities of how this can be done and hopefully replicated in future classrooms, communities, and schools. While each instructor has a unique facilitator style, both are rooted in Knowledge Building practice, leading to shared epistemic agency. Through their cooperation as instructors and amongst the students, students had agency on how they wish to approach the topics in the course to have students see connections across ideas.

Courses Overview

The first course, AP Biology, is under the guidance of the Advance Placement (AP) course regulated by the United States College board. This course is deemed to be college-level curricula and provides this intro-level college class experience while still in high school. Many were devoid of taking several AP courses during their high school career. Most students decide to pursue an AP whenever possible to demonstrate that they want to challenge themselves and are ways to demonstrate genuine academic interest as a scholar. The second course was Argumentation/ Reasoning Course. This course was developed as a philosophy course which goal was to cover concepts such as Syllogism, proportional reasoning, fallacies. Heuristics, biases, and the differences in good and bad arguments. The learning goal for the course was the following: to engage students in a Knowledge Building experience that motivates them to learn deeply about their emerging ideas and questions around the general topics of the class and implement formative assessment in such a way that individual and group learning are continually measured, and there is no room for cheating. Now two unique topics, Biology & Argumentation, as separate courses, can be seen as complimentary through the Knowledge Building pedagogy as the anchor that bridge the two courses together. As the courses were co-occurring, each class was working within their class, but in the final classes of the course, the teachers would share their classroom time to work on the shared final artifact.

In order to demonstrate the skills from the reasoning course as well as the information from the AP Biology course - students were tasked with solving a complex problem and crafting arguments on certain personas based upon actors within an Ecotourism case study. This case study was to serve as an artifact that was of value to the community. This was put forth as an "epistemic performance task" so that as an important issue of ecotourism, students could justify the important problems and questions and utilize the most valuable knowledge they have acquired from their

two classes to work together. The questions about the ecotourism case were to look at the conflicts and dilemmas that exist among the personas and their views and effects within Costa Rica's and U.S Business presence. This activity looks at the impact of the environment, local wildlife, agricultural, as well as economic factors.

In particular, this paper aims to explore and answer the following two questions:

Question 1. To understand how students utilized Systems thinking within the joint courses, we wanted to look at the student's discourse, what discourse students showcase, and whether their ideas transcend beyond the expert discourse?

Question 2. What examples came out of the student's reasoning examples and rationale used to demonstrate their viewpoint?

Methodology

Research Context & Participants

This study consisted of a cohort of nineteen students (11 boys/ 8 girls) that took both the AP Biology class and the Reasoning/ Argumentation class. Each consisted of a unique teacher, but both committed to collaborating with an overlap in using Knowledge Building and Knowledge Forum, with a culminating activity of a final white paper project that would consist of Knowledge Overlapping between both course materials. For the student's final assignment, the white paper was an Ecotourism case. Students were presented with a case study that examined a biological reserve in Costa Rica and with profiles of several characters who are affected by the plan of ecotourism, farmers, poachers, family members suffering from loss of income needed with tourism being banned in the region, an NGO leader from the United States, a U.S trade representative, a biological reserve worker, an environmentalist, and a state official. We can see that dilemmas exist among these persons, and conflict arises specifically with different worldviews and varied economic standpoints. Students were taking classes over hybrid measures based on local public health guidelines. Some classes occurred online through zoom, while others were in person, or a mix of some students online and the remainder in person. There was a total of 398 contributions in the Knowledge Building AP Bio community & 212 Contributions in the Reasoning Knowledge Building Community*. (*Note – that in the Reasoning Community, there were an additional 12 other students who were not a part of this collaborations' we removed their notes from this count.)

Data Collection

To investigate how students proceeded within the course, we will examine the discourse through two methods. Firstly, ethnographically, we will produce the participants' views through student-generated quotations and tools to mediate and produce a has the final word on the interpretation and presentation of the culture and findings (Van Maanen, 1988). Firstly, we will generate at the word clouds comprised of student online discourse contributions and another word cloud in contrast to that of the APA Bio wordlist. Secondly, we will analyze the connections between students within the community and between word co-occurrences with KBDeX (Knowledge Building Discourse explorer), a network analysis tool (Oshima, Oshima & Matszawa, 2012). We specifically looked at the student network and the word network. This would inform us of the connectedness through the co-occurrence of topics regarding discourse contribution and through the investigation of semantic connection within the communities' online contributions. Here again, we generated a wordlist based upon the Advanced Placement Biology wordlist. Finally, we will examine specific vignettes of student's responses of how they contributed to the final whitepaper and what evidence demonstrates some examples of reasoning and content knowledge to help advance their own positions.

Findings & Discussion

The word cloud under Figure 1 represents all the student discourse across all views within the AP Bio community. Figure 2 depicts the wordlist based on the discipline's glossary terms from the Advance Placement Biology wordlist.

By utilizing word clouds, we wanted to get a visual overview of the discourse students utilized to provide some context of the big ideas running throughout the course. By having a comparison of student-generated discourse to

that of discipline glossary terms, we can see how students overall are meeting or surpassing curriculum guidelines. It is evident that just the use of these terms alone does not constitute deep idea generation but provides us with context surrounding how concepts are interrelated. In addition, we can see areas students were discussing. As we can see, overlap with some discourse terms between Figure 1 & Figure 2.

In response to question 1, we can see that students overlap across the two-word clouds, specifically with terms such as cells, immune, immunity, genetic/genes, differentiation, alleles. These terms are generalized ideas, and as we can see within Figure 1, students go into specific case scenarios such as melanin, HIV, pigmentation, disease, blood, and recessive. Using the particular case study examples, we can see how they have applied such generalized terminology to more unique and specific cases. We also note that the generalized terminology looks more specifically at cell-related discourse. Finally, we note that this terminology can assist in looking at specific cases for the final white paper in the course, as students can use such examples to then rationale their reasoning but then to also provide context to their produced examples of systems thinking (Arnold & Wade, 2015) across contexts.

Figure 1. - Word Cloud of Student Vocabulary across all Student notes, Across the entire AP Bio KF community

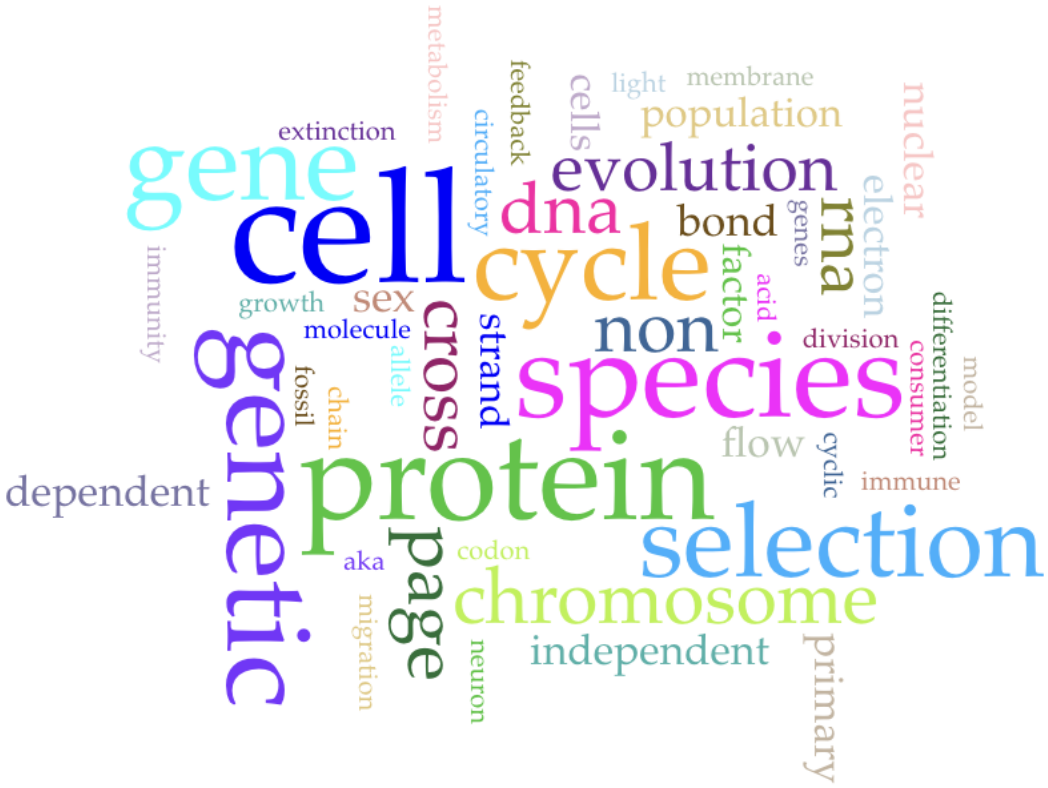


Figure 2. –Word cloud comprised of Expert corpus based upon AP Biology Wordlist

KBDeX produces content-based social network analyses based on the co-occurrence of terms among students of select vocabulary extracted from the AP Bio wordlist. These analytic methods were used to explore the emergence of domain-specific vocabulary and engagement patterns to characterize discourse usage across student works. Student discourse entries on Knowledge Forum were exported into Knowledge Building Discourse Explorer (KBDeX) (Oshima, Oshima, & Matsuzawa, 2012). KBDeX was used to explore the emergence of select Biology terms in student discourse and to assess patterns of engagement surrounding those terms.

For this investigation, the word list for KBDeX analysis was compiled from the Advance Placement Biology Wordlist. Accordingly, results reported below in figure 3 and Figure 4 show connectedness between students based on their use of the biology vocabulary extracted from these guidelines. Results derived from the Knowledge Building discourse analysis tool, KBDeX, showed the emergence of domain-specific vocabulary in student discourse and patterns of engagement surrounding the use of those terms. These words served as "expert vocabulary" to determine the extent to which students were including beyond biology, but as well with scientific merit—specifically, the understanding of biological configurations.

Figure 3 shows that students were well connected, and as we look to the lower half outer portions of the connections – these are co-authored notes which still are connected, just not as much. We can note that this community is extremely well connected, and that teacher's contributions are removed, as we wanted this to be student-focused

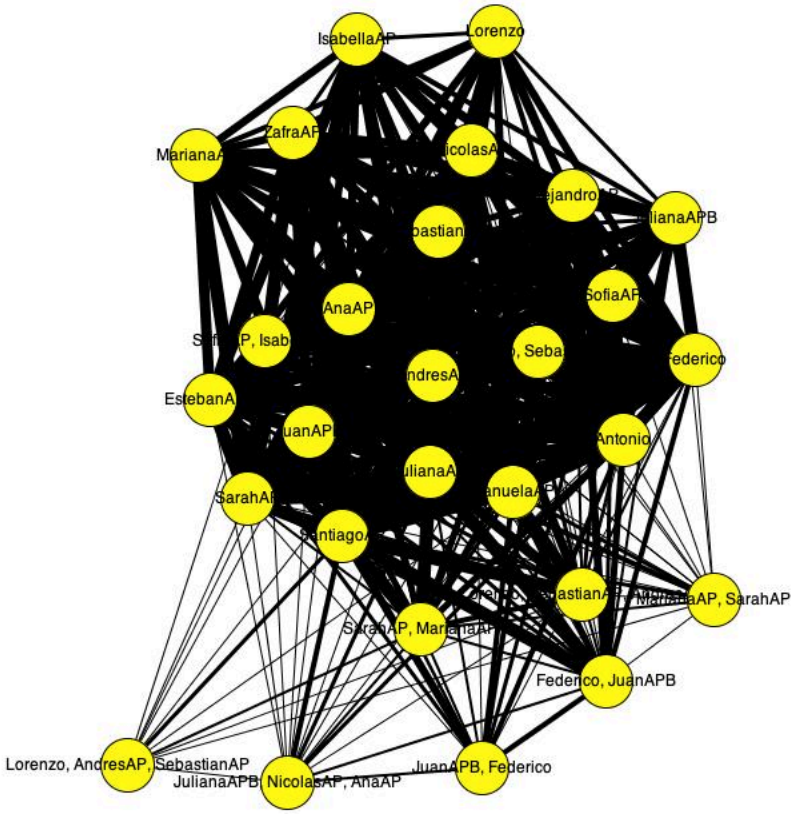


Figure 3. – Knowledge Building KBDEX Student Network Visual.

Within Figure 4, we see that students went beyond the Advanced Placement Biology curriculum and incorporated terms related to the whitepaper, which spanned across scientific thinking and rationale ideas. There is an overlap between health, climate change, humanity, and animal biology. We see connections to words such as climate change, endangered species, ecosystem, biodiversity, urbanization, vaccination, phenotype, population, and chi-square. These terms have evidenced that ideas can span across topics of expertise to provide rationale and what we can term "Idea Trajectories."

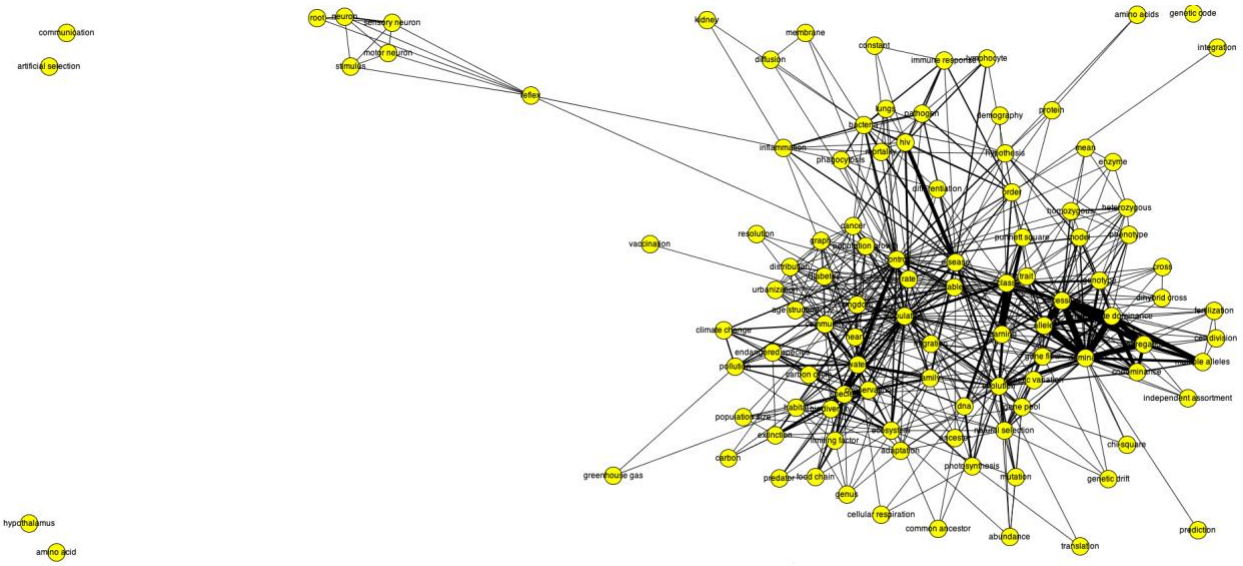


Figure 4. – Knowledge Building KBDEX Word Network

Below are three student excerpts that utilized reasoning that students have learned how to do, as well as some information they acquired in their biology class to signify their understanding of a new complex problem presented to then and the application of such ideas in new contextualized manners. In example one, we see an example of inductive reasoning. The MSR student, provides observations that are specific to a generalized conclusion. By looking at issues with the Macao bird, then generalized to biodiversity affects in Costa Rica, we see the student not just putting forth an opinion but taking expert corpus and authoritative sources to support their viewpoint of concerns with poaching within the discipline of ecotourism.

"- If the biodiversity of Ara Macao is reduced, then the length of the predator-prey cycle will be affected in the Costa Rican territory. The Ara Macao are animals that belong to a food chain; therefore, if they are extinct, the predators will be affected by starting to disappear and decrease the amount of population that at the end changes the equilibrium of the environment. Based on different studies made by the Amazon Aid Foundation developed over the last years, the main predators of these animals are most giant birds of prey, snakes, and monkeys. This food chain, usually without any limiting factor, can maintain a balance among species for not affecting the population capacity of the environment. If there is a reduction in the Ara Macao population, competition will occur among predators causing a collateral effect based on the depletion of the length of the predator cycle. This is due to when the population becomes crowded, and in the end, only one can win the food, water space, sunlight, and other essential factors for their survival. Therefore, if poaching continues affecting the biodiversity of the Ara Macao in Costa Rica, then its predators would not have any prey to feed themselves nor enough supply of food to remain alive." – Argument from MSR Student

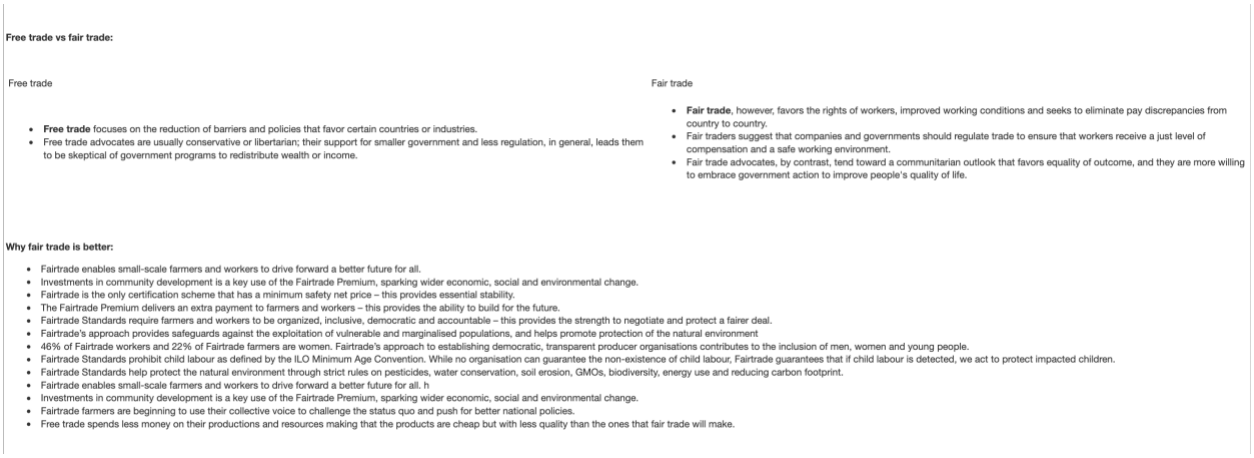
In excerpt number 2, this student takes an alternative approach with limited evidence to support their reasoning. Here we see an example of abductive reasoning, while we can see the student example provides examples there is not enough support but provides useful earlier steps to form a hypothesis for further investigation. A clearer explanation would have been beneficial.

***"**- Ecotourism harms the environment because, as the profit from this activity starts to rise, the protection of nature and local environments becomes a secondary problem; the government would focus all the attention on profit maximization. **Supporting ideas and evidence:** We can see that ecotourism affected and disrupted local economic activity. The financial benefit of ecotourism in some areas also does not benefit the local community. According to BBC news, rather than locals being compensated for switching to work in the tourism industry, they often receive low-paying jobs. Ecotourism is turning into a large enterprise, and there are not enough regulations to control how it is operating. The destruction of local resources to make room for ecotourism is a problem, given that essential plants are being destroyed or taken down to construct a tourist center; for example, trees felled to make lodges for tourists, this shouldn't be allowed, how can they take our land away and destroy it for building in it? Natural*

resources are destroyed to make souvenirs, and rare species are hunted down to use as tourist attractions; animals shouldn't be seen as tourist attractions. They are living things (animals) with needs that are not entirely accomplished in a tourist attraction. Another essential aspect to consider is the destruction of natural features present in ecotourism (components and processes present or produced by nature such as vegetation, drainage patterns, climate, etc.); an example given by BBC news is that overused tracks lead to soil erosion and damage to vegetation. This leads us to the next issue of ecotourism: there is a real danger of some areas becoming overused, in other words, large footprints that cause climate change and risk for species and the environment. Tourist hotels sometimes dump waste into rivers causing water pollution. Don't you think that ecotourism does more harm than benefit? "– Argument 6 from SBC student

Here in this final example, the student proposed an alternative argument to advocate that Ecotourism is a beneficial activity and within this they provide an in-depth example of deductive reasoning to exemplify how related issues such as Fair trade can be a precursor to provide livelihoods to local families while also taking care and preservation of specific ecological matter without the distraction of it. In the example below we see ideas transcend across issues, and ideas are overlapped in references in interconnectedness of how one area affects and can have a profound impact on other dynamics.

"Ecotourism is an eco-friendly activity. - Explanation: "Ecotourism operates for one or more of the eco-friendly alternatives for the economic use of natural resources compared with mining, hunting, farming and so on (Li, 2006). Ecotourism promotes an enhanced appreciation of natural environments and environmental education by exposing visitors and locals to nature and conservation (Bob et al., 2008). " "Ecotourism is largely perceived to safeguard natural areas and thereby to contribute to the conservation of biodiversity. It focuses primarily on experiencing and learning about nature, its landscape, flora, fauna, and their habitats, as well as cultural artefacts from the locality. In ecotourism planning, the first issue that emerges is the environment and its conservation "



Free trade vs fair trade:

Free trade

- **Free trade** focuses on the reduction of barriers and policies that favor certain countries or industries.
- Free trade advocates are usually conservative or libertarian; their support for smaller government and less regulation, in general, leads them to be skeptical of government programs to redistribute wealth or income.

Fair trade

- **Fair trade**, however, favors the rights of workers, improved working conditions and seeks to eliminate pay discrepancies from country to country.
- Fair traders suggest that companies and governments should regulate trade to ensure that workers receive a just level of compensation and a safe working environment.
- Fair trade advocates, by contrast, tend toward a communitarian outlook that favors equality of outcome, and they are more willing to embrace government action to improve people's quality of life.

Why fair trade is better:

- Fairtrade enables small-scale farmers and workers to drive forward a better future for all.
- Investments in community development is a key use of the Fairtrade Premium, sparking wider economic, social and environmental change.
- Fairtrade is the only certification scheme that has a minimum safety net price – this provides essential stability.
- The Fairtrade Premium delivers an extra payment to farmers and workers – this provides the ability to build for the future.
- Fairtrade Standards require farmers and workers to be organized, inclusive, democratic and accountable – this provides the strength to negotiate and protect a fairer deal.
- Fairtrade's approach provides safeguards against the exploitation of vulnerable and marginalised populations, and helps promote protection of the natural environment
- 46% of Fairtrade workers and 22% of Fairtrade farmers are women. Fairtrade's approach to establishing democratic, transparent producer organisations contributes to the inclusion of men, women and young people.
- Fairtrade Standards prohibit child labour as defined by the ILO Minimum Age Convention. While no organisation can guarantee the non-existence of child labour, Fairtrade guarantees that if child labour is detected, we act to protect impacted children.
- Fairtrade Standards help protect the natural environment through strict rules on pesticides, water conservation, soil erosion, GMOs, biodiversity, energy use and reducing carbon footprint.
- Fairtrade enables small-scale farmers and workers to drive forward a better future for all. h
- Investments in community development is a key use of the Fairtrade Premium, sparking wider economic, social and environmental change.
- Fairtrade farmers are beginning to use their collective voice to challenge the status quo and push for better national policies.
- Free trade spends less money on their productions and resources making that the products are cheap but with less quality than the ones that fair trade will make.

Figure 5. – Student chart of an in-depth understanding of Fair-trade pros and cons.

Students presented a meta-level discussion in biology. Within the reasoning course, they took the information they learned and applied it within a new context to answer questions and apply the foundational Biology knowledge to working with complex problem-solving. While the paper provides a snapshot of some course examples solely, we believe that not whole reasoning and logical conclusions were utilized in their fullest sense here. However, despite this, the research paper acknowledges these challenges as opportunities to be examined further in understanding how we can examine innovative idea trajectories and go beyond the sharing of knowledge, but instead, be embed ways to innovate with more explicit examples of reasoning. This paper is the first to support the same cohort Knowledge Building, simultaneously with two Knowledge Building teachers with unique content, sharing the same cohort of students. We believe that Collaborative Justification (Kopp et Mandl, 2011), a theoretical phrase referring to a learner's justification for arguments were evident and supported during a collaborative task was evident.

In closing, we hope this paper will provide us with a new avenue to open new research opportunities for collaborators to share their classrooms among the same cohort of students, when possible, in high-school settings.

Studies like this provide examples of how students' learning trajectories go beyond a single subject and have intertwined ideas that allow students to create well-justified arguments. As noted in this paper, just learning discourse and content within a subject matter is not enough, but together with understanding how an argument can be applicable to new situational complex problems and new ways to connect knowledge beyond the set subject.

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Applying Knowledge Building to Improve the Instructional Design Abilities of Novice Teachers

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Abstract: With limited experience in teaching practice, novice teachers will encounter numerous real problems that are difficult to solve ,if they only use their original efficiency-oriented strategies to find "standard answers" from textbooks or their existing experience. Innovation-oriented ability is highlighted to deal with these authentic teaching problems. In this research, we used knowledge-building (KB) theory to guide a training community of 35 novice teachers who have been working for one month. The training offered three months of online discussion on a Knowledge Forum and seven face-to-face offline meetings every two weeks. The main training process had three phases: problem proposal and interpretation, negotiation and continual improvement, and rise-above and practical application. We analyzed the "efficiency-innovation" orientation teaching design based on six dimensions of a teaching plan and teaching strategy. The findings illustrated that KB-based teacher training changed novice teachers' instructional ability from an efficiency orientation to an innovation orientation, namely: (1) from the perspective of the problem proposal and solution process, the novice teachers were able to identify the nature of problems that arose in teaching; (2) from the perspective of idea improvement, novice teachers were willing to transform to a deeper understanding of innovative teaching; and (3) from the perspective of artifact production, novice teachers formed a relatively preliminary theoretical system of innovative teaching.

Introduction

Although an efficiency-oriented teaching method can quickly achieve the established teaching objectives and thus improve students' routine expertise, it leads to the lack of students' adaptive expertise, an important dimension of which is innovation (Hammond and Bransford, 2005). In the traditional industrial model of education and training, which emphasizes standardization, structurization and efficiency, training activities are mechanical and routinized, and are separated from the complex problems rooted in the real situation (Hong and Chai,2017). In this case, the learner's unsolicited ideas are often unwelcome or ignored. According to the researchers' understanding of the training status in recent years, the trainees, on the one hand, are dissatisfied with the "lecture-style" training and think they have not gained much information. On the other hand, they expect "famous experts" to bring wonderful "programs." As time passes, this teacher training becomes an administrative task, and trainees can leave the classroom after finishing training assignments. Both training efficiency and enthusiasm of trainees are low. To a great extent, this has restrained trainees' creativity. Obviously, transmitting enough knowledge is far from sufficient to solve such a complex problem. Learners need to be guided into a culture of knowledge creation (Sawyer, 2006) for exploration. More emergent and self-organizing activities (rather than completely presetting or following a conventional teaching mode) need to be allowed to realize the transformation from efficiency-oriented to innovation-oriented teaching (Bereiter and Scadamalia, 1993).

Innovation-oriented teaching focuses on authentic problems and gradually improving teaching practice rather than imitating model teaching (Hong and Chai,2017). In the long run, innovation-oriented teaching can help novice teachers develop adaptive expertise and become innovative knowledge workers. Many empirical studies have shown that, for teachers, the excessive pursuit of efficient lesson planning may lead to deficiencies in critical and reflective thinking. Thus, it is necessary to carry out an innovative teaching practice reform (Radloff and Guzey, 2016; Rusche and Jason, 2011). The principles-based KB teaching method requires teachers to change the practical concept of following the specific teaching activity structure (Campione et al., 2007). The ability to help future teachers transform from "knowledge porters" to "knowledge workers" who can solve problems step by step and to train teachers with innovative teaching abilities rather than experienced nonexperts are challenging problems to be solved.

Bereiter and Scadamalia (1993), the founders of knowledge-building (KB) theory, opposed efficiency-oriented teaching and teachers' teaching expertise should be oriented toward progressive and real problem-solving ability. Increasingly, researchers have realized that whether teachers' teaching is oriented by efficiency or innovation is the key to teaching reform. Making future teachers become knowledge builders to conduct innovative teaching is a promising approach in teachers' professional development (Chai and Tan, 2009; Chan and Aalst, 2006; Hong et al., 2011), and in KB environment, one of the most important principles is to start with authentic problems. Therefore,

starting from the real teaching problems faced by novice teachers, to improve trainees' innovative teaching ability, this study conducted online and offline training for three months using the KB teaching method. This study mainly solved the following three research questions: (1) From the perspective of the process of problem proposal and solution, can novice teachers have insight into the essence of authentic problems in teaching? (2) From the perspective of the process of idea improvement, can the novice teachers overturn the original solidified cognition into a deeper innovative understanding of teaching? (3) From the perspective of the production of artifacts, have novice teachers formed a relatively systematic and innovative teaching theoretical system?

Methods

Participants and Instructional Context

This study conducted a training project for novice teachers in secondary vocational schools organized by Nanjing Vocational Education Institute. The training subject was "Instructional System Design." After excluding seven people who did not fully participate in the KB process (e.g., missing more than half of the classes and not submitting works), we had 35 trainees (14 males and 21 females) from 19 secondary vocational schools in Nanjing, China. In this paper, we refer to the 35 novice teachers who received training as the "participants." Novice teachers and trainees both are referred to as participants. "Students" refers to the students taught by these novice teachers.

Instructional Design

The training team was composed of a university professor with more than 10 years of experience in KB teaching and research, four postgraduate teaching assistants, and a teacher in charge of the Nanjing Vocational Education Teaching and Research Office who is familiar with the training process and could coordinate or decide on the training method and content. The training lasted for three months, once every other week, and consisted of seven face-to-face meeting classes with each time lasting for 2.5–3 hours. In total, the training time included about 28 class hours.

To facilitate trainees' free combination and interactive discussion, the classroom had movable desks. Trainees were encouraged to bring their own laptops to the classroom. An online platform, Knowledge Forum (KF), was also used for training, which enabled trainees to propose their real ideas, comment on or question others' ideas, and make continuous improvement of ideas. Following the KB teaching process and combining the class schedule for this training, we divided the research into three phases: problem proposal and interpretation, negotiation and continual improvement, and rise-above and practical application. The specific teaching practice and research process are shown in Figure 1.

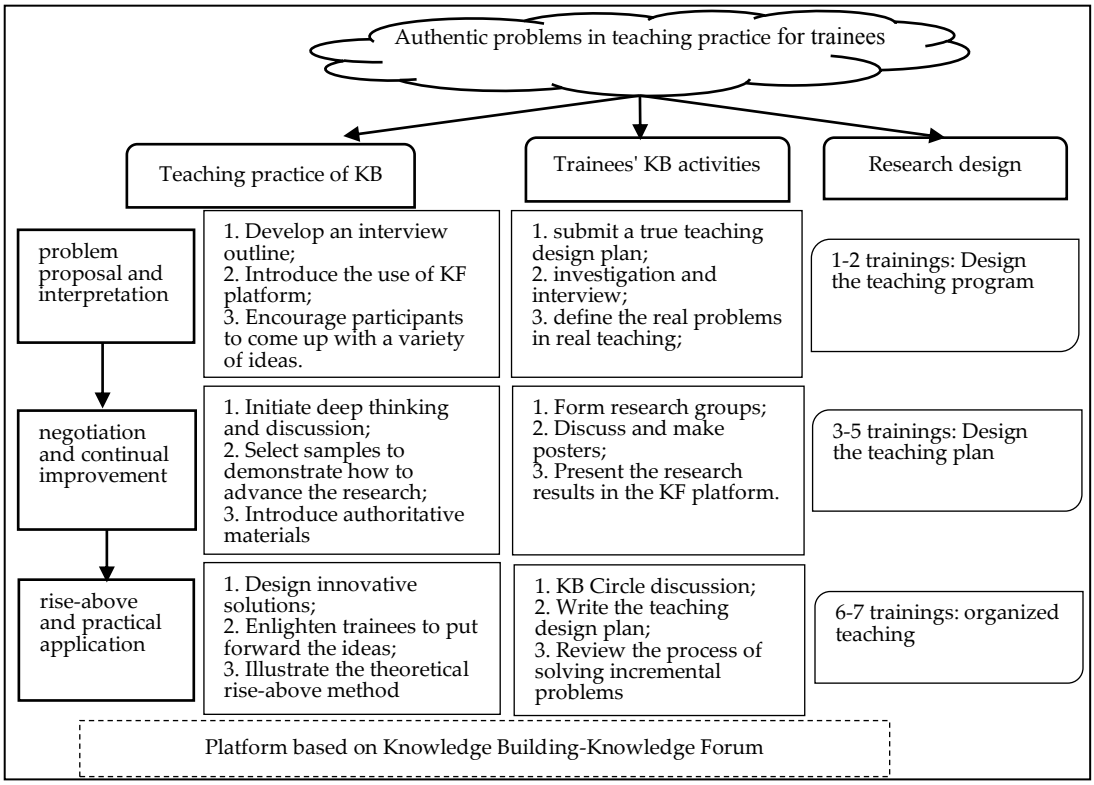

Figure 1. Teaching practice and research process.

Data Sources and Coding Schemes

The continuous improvement of ideas and the formation of conceptual artifacts are the core of KB teaching. Therefore, we analyzed whether the instructional design of novice teachers was "efficiency-oriented" or "innovation-oriented" by tracking their ideas and artifacts published on the KF platform. We obtained a total of 417 valid ideas on the KF platform, and artifacts included 70 teaching design plans and 27 group posters. The 70 teaching design plans represented 35 pre-tests and 35 post-tests. We also collected recordings of classroom discussions and interviews. The data analysis was based on the ideas and teaching design plans on the KF platform and was supported by other materials. Strauss and Corbin developed a system of teaching improvement open coding (efficiency-oriented versus innovation-oriented) (Anselm and Juliet, 2006). Based on this system, Hong and Chai (2017) determined 12 different threads of inquiry. In this study, we adopted this content coding system, which was classified according to the six dimensions shown in Table 1.

Table 1: Teaching improvement (efficiency-oriented versus innovation-oriented) coding system

	Efficiency-Oriented	**Examples of Trainees' Ideas**	**Innovation-Oriented**	**Examples of Trainees' Ideas**
Teaching Plan	Control over lesson plan	The number of minutes spent in each section of the class should be controlled, or I may feel unable to continue.	Adaptability in teaching design	We must make some adjustments according to the acceptance of the students.
Teaching Strategies	Control over teaching strategies	We can save time in class by putting some concepts and examples in the courseware in advance.	Flexibility in teaching strategies	We can ask students to express their ideas and give reasons.
Class Activities	Control over class activity	They need to do enough exercises before the next knowledge point of learning.	Interactive discussion in class	We can combine examples from students' own lives, such as their own experiences with computers.
Teaching Methods	Control over presentation skills	The experienced teacher told us that we must practice the fundamentals of teaching.	Open and engaging learning	I find that sometimes a humorous way can attract students' attention, make the class interesting and open.

			environments	
Teaching Content	Control over what to teach	As a novice teacher, I worry that students will ask me what I don't know in class.	Improvised learning activities	We should be respected for their ideas and questions, which are what they are interested in.
Study Materials and Tools	Control over the use of teaching aids	PPT should be used to show the content so that students will be more efficient in practical operation.	Creative use of learning materials	Some concepts and formulas can be explained in combination with other course materials.

This content analysis method is suitable for the inquiry process oriented toward real problem-solving. According to the six dimensions of measuring teaching orientation, trainees will have more efficiency-oriented or more innovation-oriented ideas. We defined the tendencies of each dimension as positive indicators (innovation-oriented) and negative indicators (efficiency-oriented), assigning +1 and -1, respectively. Referring to the calculation method of critical-thinking depth (both positive and negative indicators tend to judge dimensions) (Newman et al., 1996), we calculated the depth of innovative teaching as follows: the number of indicators coded as +1 and -1 was counted, and then the difference between the numbers of the two was divided by the sum of the numbers of the two, as follows:

$$X = (X^{+}-X^{-}) / (X^{+}+X^{-}), \quad (1)$$

where X is the depth of innovative teaching, and X^{+} and X^{-} are the number of positive and negative indicators, respectively. The depth of innovative teaching is between -1 and +1. A negative value represents the more efficiency-oriented teaching, whereas a positive value represents the more innovation-oriented teaching. The greater the absolute value of depth, the stronger a certain tendency. Two researchers sorted the data according to the process of problem analysis and solution, extracted the precoding of some ideas in each phase, discussed and negotiated the inconsistent results repeatedly, and reached a consistent understanding of the coding system. The consistency test of coding results showed that the Kappa coefficient was 0.822, showing good consistency.

Results

Corresponding to the three research questions, we analyzed the results according to the following three aspects: (1) trainees' insight into the nature of the real problem was analyzed through the distribution of the occurrence rate of various dimensional ideas; (2) trainees' efficiency-innovation-oriented cognitive shift was analyzed through the phase change of depth of perspective; and (3) the level of production of conceptual artifacts represented whether trainees had formed a theoretical system of innovative teaching.

Trainees were able to identify the nature of problems that arose in teaching

Although the depth of ideas for each dimension in the phase of problem proposal and explanation was very low, trainees expressed a significant number of ideas; in particular, they paid great attention to teaching methods and class activities. These ideas, however, tended to be more efficiency-oriented, which showed that during the early phase, trainees focused more on how to improve the students' interest in learning and on some external, shallow problems, as well as some student management problems. They pursued novel and fancy teaching methods, advanced and cutting-edge software technology, and attractive situational introduction. In this way, they attributed students' low academic performance to outdated teaching methods and strategies.

The dimensions of teaching contents and study materials and tools received the least attention, and this did not change much—even in the last phase of training. Some trainees stuck to the idea that if teachers gave students a glass of water, they should have a bucket of water first. They regarded themselves and students as containers, and believed that they would be ashamed if students asked questions they did not know the answers to, such as "I didn't have enough time to prepare for the class, so I went in class in a panic. I was afraid that students would suddenly ask questions that I hadn't prepared for" (S1).

Trainees were willing to transform to a deeper understanding of innovative teaching

Principles-based KB teaching is centered on the continuous improvement of ideas, and this represents the change in the process. To analyze the change of the depth of trainees' idea at each phase, the researcher selected the most obvious dimension of each idea to encode and calculated the depth value of 417 ideas on the KF platform. The results are shown in Figure 2.

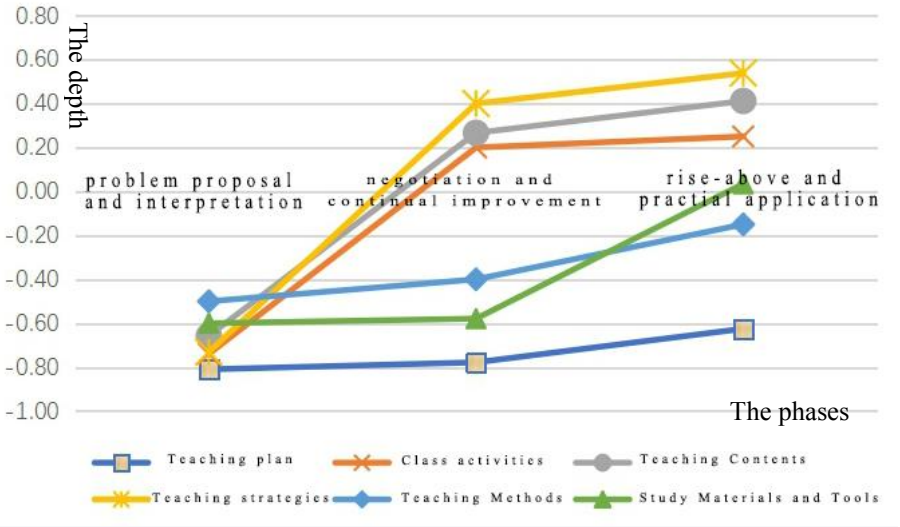

Figure 2. Phases of depth change

On the whole, the depth of each dimension followed an upward trend over time. At first, six dimensions were negative and were obviously efficiency-oriented. Among them, teaching methods, class activities, and teaching strategies increased rapidly at first and then increased slowly in the second phase. The three dimensions of teaching content, study materials and tools, and teaching plan grew extremely slowly in the first phase. In the later phase, teaching content and study materials and tools increased a little, but the final depth of the two dimensions remained very low. The depth of the teaching plan did not increase significantly in the final phase. This showed that the development of teaching methods, class activities, and teaching strategies mainly occurred in the early phase of training. This occurred mainly because the real teaching questions raised by the trainees in the "problem proposal and interpretation" phase were homogeneous. Therefore, this struck a chord with most people and triggered a heated discussion. Another possible reason is that trainees took different subjects, so the discussion on the course content was difficult to go further. The development of teaching content and study materials and tools mainly occurred in the later phase, which indicated that trainees gradually deepened their understanding of the specific course content on the basis of previous discussions. There was no significant change in the dimension of the teaching plan. This may have pertained to rigid management systems in the schools where the trainees were working. The teaching management department required trainees to use a uniform teaching design template and even stipulated the content and rhythm of certain classes.

Trainees formed a relatively preliminary theoretical system of innovative teaching

We used the 70 teaching design plans submitted by the trainees before and after the training as the pre-test and post-test data to count the positive and negative indicators of the six dimensions. The researchers used the formula to calculate the depth of innovation orientation; the results are shown in Figure 3.

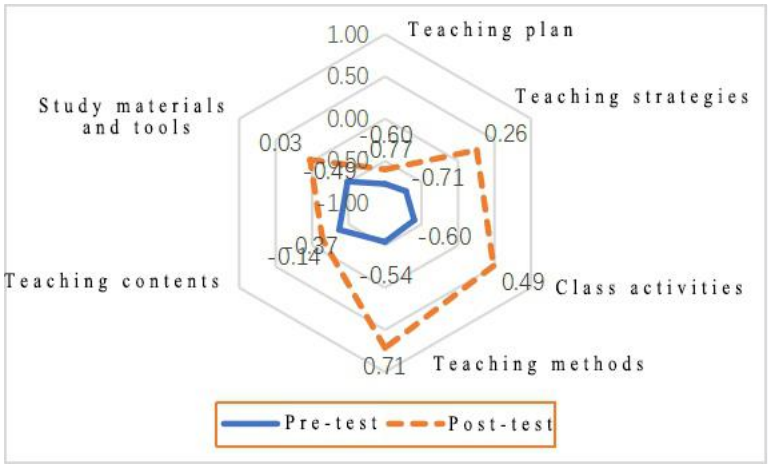

Figure 3. Depth of first and last teaching design

The depth of the six dimensions of the pretest was negative, and the overall depth was -0.58, indicating that trainees' teaching plan was a typical efficiency-oriented design. After three months of KB training, the post-test data showed that all dimensions improved and four became positive. The overall depth was 0.12, which indicated that the overall depth improved significantly, but the post-test innovation depth still was not ideal. Specifically, the changes in teaching methods, class activities, and teaching strategies were the most obvious. In the pre-test, more than 90% of trainees regarded the lecture-based learning as the primary and most commonly used teaching method, and they paid attention to the artistry of teaching skills. In the post-test, more attention was paid to the interaction with trainees, group discussion, projects and other activities, and methods.

Although the dimensions of teaching plan and teaching contents improved slightly, they still were negative and tended to be efficiency-oriented. The interview results of some trainees also supported this finding. The cookie-cutter instructional design was filled with numerous, even minute-accurate plans (such as introducing a new lesson in the first four minutes), routines, and scripts. When teaching plans conflicted with students' class improvisation, the latter often succumbed to the former, and improvisation was ruthlessly ignored. The highly structured script teaching design occupied the space of creative teaching, which led to problems in the trainees' teaching, such as the simplification of complex problems and the lack of progressive thinking to solve problems. There are two possible reasons for the difficulty in changing these two dimensions: first, the novice teachers had little control over the class; and second, trainees' ingrained thinking mode influenced their teaching. Most preservice teachers held the teaching concept of knowledge transfer, and they taught in the way their teachers taught them (Northfield and Gunstone, 1983), continuing to duplicate excellent teachers. Therefore, even in group discussion or project-based teaching, trainees often were unable to escape the control of strict teaching plans, such as the size of the group, the length and content of the discussion, and the fixed number of student seats.

Discussion

On the whole, there was an obvious improvement innovation-oriented teaching in the training for the professional development of the novice teachers. Most novice teachers are in a state of growth, and the concept of innovation has changed significantly. The six dimensions of teaching orientation development, however, have not been balanced. The main changes in the three dimensions were as follows: in teaching methods, from programmed transmission teaching to principle-oriented open teaching; in terms of teaching strategies, from imitating "experienced non-experts" to gradually improving teaching practice; and, in class activities, from process-based activity organization to discussion centered on students' ideas.

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Knowledge Building Metaspace: Designs for (Re-)Distributing Expertise and Advancing Knowledge for Public Good

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Abstract: The principle of symmetric knowledge advancement suggests that "to give knowledge is to get knowledge", yet in schools, outdated beliefs about knowledge and expertise persist, often reducing students as passive receivers of knowledge. In this paper, we aim to address this challenge in the most direct means possible by repositioning students as epistemic agents and transforming the constraints of pandemic learning into opportunities to promote cross-community collaboration with experts in local as well as the global communities. We present two examples of symmetric knowledge advancement in K-12 schools: one in a primary class and one in a secondary class. Implications of classroom designs are discussed within the context of designing a global metaspace which aims to invite Knowledge Builders of all ages located anywhere in the world to contribute ideas to help close the gap between schoolwork and knowledge work in the world and advance the vision of education for knowledge creation.

Introduction

One of the core challenges of aligning education with the needs of knowledge creation is to make the production and utilization of knowledge pervasive (Tan et al., 2021). Authentic knowledge work goes beyond the wall of classrooms to the conceptual and social spaces in which ideas live, with students feeling at home in World 3 (Horner & Ma, 2020). The principle of symmetric knowledge advancement suggests that "to give knowledge is to get knowledge" (Scardamalia, 2002) and encourages cross-community collaboration to facilitate the flow of ideas within and across communities for more powerful conceptual advances (Zhang et al., 2018). In this way, Knowledge Building becomes pervasive — it can happen anywhere, anytime, with anyone.

The challenge for the classroom teacher is to build a culture in which knowledge is democratized for all and each and every student is recognized as a legitimate contributor to community knowledge advancement. In a Knowledge Building community, the teacher must actively work toward shifting traditional relations between students' ideas and experts' ideas (e.g., curriculum, textbooks, and so on) so that students are positioned as epistemic agents in working constructively with authoritative sources (Teo, 2014). Even if experts were to be invited into the classroom, interactions between students and experts would need to shift from students asking questions to receive knowledge from experts — knowledge that is perhaps not found in textbooks — to students sharing collective advances with experts and engaging experts in Knowledge Building discourse to integrate and improve ideas across sources while identifying emergent knowledge problems for which there is no existing answer. It is through intentional, sustained efforts to make shifts in interactions that facilitate the flow of ideas within and across communities that we are able to advance the vision of education of knowledge creation.

This paper aims to address these range of challenges by connecting classrooms with experts in local as well as the global communities. In the first example, a primary class in Canada studied the salmon life cycle for six months and connected with an ecologist who specializes in salmon restoration and an organization that creates solutions for habitat restoration. In the second example, a secondary class in Catalonia studied olive oil for seven months and connected with a local expert who specializes in agriculture techniques and an international expert on plant developmental biology and genetics. The pandemic has made virtual learning a mandatory component of teaching in many ways, and in the examples to follow, the teachers have transformed this constraint into opportunities to promote cross-community collaboration and symmetric knowledge advancement. This paper will conclude with teachers' ideas for cross-grade, cross-community designs to deepen student learning in the upcoming school year, with possible design ideas for a Knowledge Building metaspace. This paper directly contributes to this year's theme of "Meeting New People and New Ideas in Knowledge Building's Metaspace".

Year 1: Designs for Connecting with Local Expertise

Primary Class in Ontario

From January to June 2021, the Grade 2 class (22 students) at the Dr. Eric Jackman Institute for Child Studies in Toronto studied the life cycle of salmon. The class shifted from in-person to online learning due to the pandemic and as much as possible, the design was adjusted to meet the teacher's and students' needs. Below we elaborate on the classroom design as it relates to the Knowledge Building principles as well as preliminary findings.

Epistemic Agency, Knowledge Building Discourse, Pervasive Knowledge Building

The focus of this design was to engage the Grade 2 class in storytelling. By incorporating digital storytelling practices within the Knowledge Building community to visualize the evolution of thought of students. Because of this, one of the key guiding principles of this design is epistemic agency. Although epistemic agency is already present in a Knowledge Building community, we sought to encourage more, by actively asking students to share their own personal narratives related to any part of their learning journey, which is at the core of digital storytelling (Lambert, 2013).

To support this goal, students used mixed modality to engage in Knowledge Building discourse and digital storytelling. To accommodate various learning needs and interests, students investigated salmon using the media with which they felt the most comfortable to convey their creative work with ideas. Modalities included but were not limited to: reading, writing, Knowledge Forum, clay modelling, expert videos, expert synchronous meetings, video journaling, and digital stories.

As an example, students input their questions in Knowledge Forum using the theory-building scaffolds of their choice. In addition, clay models or digital stories gave students an avenue to implicitly work through ideas and 'show' a deeper and more nuanced understanding of salmon that sustained class discussions alone could not have possibly represented. The choice of modality also led to pervasive Knowledge Building — students were able to draw upon their lived experiences inside and beyond the classroom to build up the community's knowledge regarding salmon, their habitat and means of creating sustainable environments.

Constructive use of authoritative sources, Idea improvement, Symmetric knowledge advancement

To expand the realm of ideas surrounding salmon, students connected with local and international experts, such as Ben Tesky and Whooshh Innovation. A crucial component of the students' investigation is the introduction of a salmon tank, and salmon eggs that the students would be able to raise themselves. However due to the pandemic, this was replaced with regular update videos from a local salmon expert, Ben Tesky, that highlighted the growth of the students' salmon eggs. In spite of this major change, the teacher noticed that through these regular check-ins, students were more connected with the salmon being raised and the expert himself. In contrast to previous years where the expert may have only shown up 2 to 3 times during a term, the students engaged in deeper discussions with the expert. Student subject-matter knowledge also increased dramatically as evident in the types of questions they asked in a final question and answer video call with the expert. As an example, they began the term asking questions such as: *Why do salmon go to the sea? Can salmon jump out of the water?* To contrast they had questions for Ben that either moved beyond their grade level such as how do salmon physically jump over a waterfall or questions that he could not answer: *How does a salmon know what to do at each life stage? How does it know how to find food or hide?* Due to high levels of interest and sustained engagement with ideas, not only did students benefit from interacting with experts, but experts also learned through their discussions with students.

Real ideas, authentic problems, Idea diversity, Democratizing knowledge

One of the big challenges students addressed during their salmon investigations was designing solutions for improving the sustainability of salmon environments with a particular focus on how salmon could traverse blockages during yearly salmon runs. Many ideas were generated by the community but a particular creative turn of discourse was initiated by the teacher as he shared the idea of a *salmon cannon*. This was further supplemented by videos of how the device worked and deeper discourse by the community. By taking this discourse a step further, the teacher connected the class with one of the inventors of the salmon cannon through a video conference call. Similar to the students' positive reactions to connecting with a local salmon expert, they were thrilled to be connecting with the people responsible for something they were only able to see in videos. The impact was profound and the teacher reflected that the inclusion of experts via video calls was something that would be incorporated into his teaching practice. Not only does it mitigate issues of time and geography, it provides a direct connection between what students are learning and experts in the field that can provide tailored answers and knowledge to student questions; dispelling misconceptions and expanding knowledge.

Preliminary analyses

This study adopted a design-based research methodology (Brown, 1992) to develop and refine new practices for digital storytelling ontext. Observations were collected for each inquiry lesson via video or audio recording, resulting in a total of 25 recordings. Design meetings and teacher interviews were conducted regularly to reflect on the progress of the student's inquiry into salmon and the introduction of various modalities of learning. All observations, interviews, meetings were transcribed verbatim, and then coded and analyzed using Bazely's (2013) framework. Students were also given the option to create short digital recordings of each stage of the salmon life cycle. The researcher then aided in editing together each students' videos into a final digital story. Of the 22 students, 18 final videos were produced and uploaded as artifacts in KF for students to further their discourse on salmon. Finally, learning analytics collected in KF were used to complement the qualitative data collected. Three KF views were used for discourse: *salmon information*, *salmon stories* and *sustainable environments*. Each view corresponded to an increase in modalities of learning. Start with typing, reading, and discourse in the *salmon information* view, then clay, drawing (digital and analog), and digital storytelling in the *salmon stories* view, and finally discussions with experts or having deep discussions regarding larger societal and environmental issues in the *sustainable environments* view and through video calls.

Diversity of Modalities

Multimodal interactions offered students multiple points of entry into learning, multiple modes of expression and gave them greater epistemic agency in their learning. From the 25 video observations, there was a fairly even distribution of modalities discussed or explicitly used, with the exception of video, which was heavily favoured (see Figure 1). One explanation for video being the dominant modality could be attributed to the norm in which students normally consume information outside of school, that is by video, through various social platforms such as Youtube. In addition, remote learning could have further influenced their choice of modality, as video is perhaps the closest to mimicking face-to-face discourse. The other modalities were more evenly represented, which could be an indication of potential barriers for expression related to technology, language or even how fun a modality is perceived.

The types of modalities that were helpful for learning and engagement with ideas were those that had a higher ratio of fun versus work. Modalities that had elements of creativity (drawing, video creation, clay modelling) allowed students to enter a state of flow where they are no longer concerned with why they are doing something because it is fun (Schmoelz, 2018). The modalities that were less common could be a result of a lack of skill or familiarity, both of which could be resolved with more time spent on those modalities. A future design iteration could seek to ask students to utilize a combination of modalities to express their ideas rather than only ones that they were the most comfortable with.

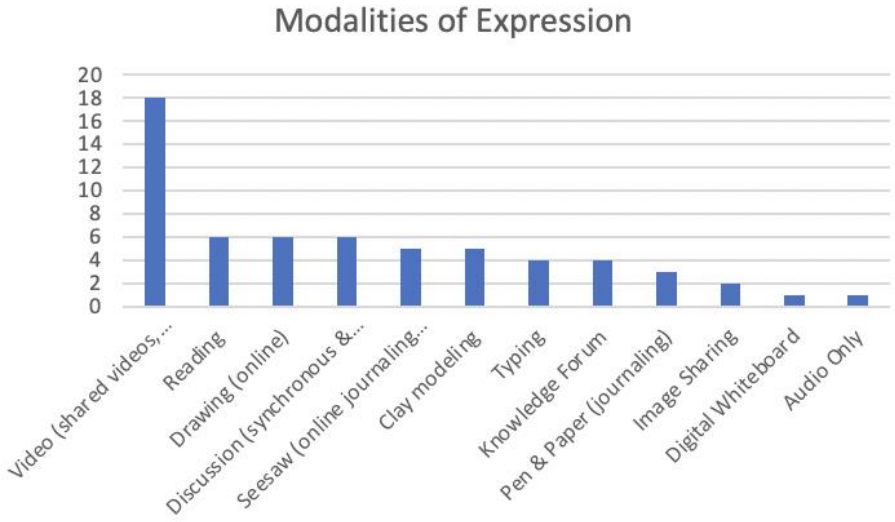

Figure 1. Frequency of Modalities of Expression during Knowledge Building

Teacher/Researcher Reflections

Digital Stories Yields New Perspectives

Digital tools enhanced how students accessed information firsthand, and how they expressed their understanding in both minds-on and hearts-on ways (Anderson, 2017.) Providing students with opportunities to display their scientific understanding through art allowed for them to represent, express, and describe in detail their depth of knowledge on the topic or relevant sub-topic. Shifting the focus away from only assessing understanding through writing skills motivated them to combine their literacy skills with various mediums. They were asked to create videos to describe in detail the aspects of the salmon life cycle and habitat that they created using natural materials and artistic tools. When the digitally recorded videos were posted in Knowledge Forum for peers to view, comment, and question, students could learn from their peers in ways that allowed them to experience different perspectives and levels of knowledge all while engaging in the same inquiry (Figure 2). Having students first articulate their ideas using digital storytelling tools followed by building on with KF scaffolds (Figure 3) offered students and their teacher a uniquely rich way of sharing knowledge and improving ideas. Lastly, the personal narratives woven into the stories of salmon led to a deeper appreciation and understanding by the students of each of their peer's journeys.

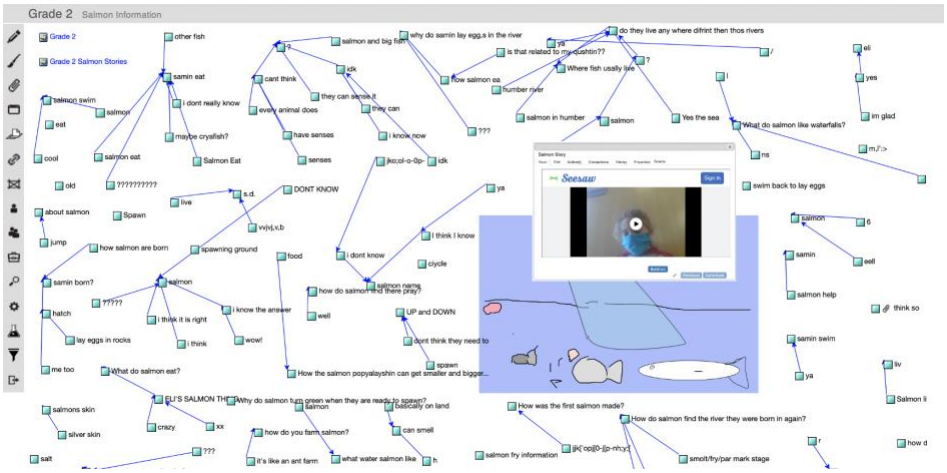

Figure 2. A Knowledge Forum view about salmon with affordances for writing, drawing, and embedding videos

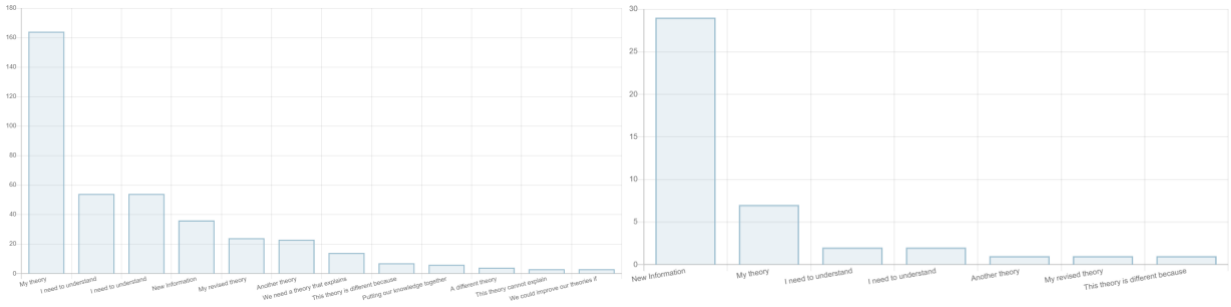

Figure 3. Scaffold growth across the first (Jan - March) and second (April - June) half of the school term

Secondary Class in Catalonia

In July 2020, Sant Pau Apòstol school in Tarragona (Catalonia-Spain) connected with Italian experts at the Instituto di Instruzione Superiore "A. Cecchi" in Pesaro to build knowledge about olive oil, particularly about agricultural techniques derived from botanical studies. Due to constraints posed by the pandemic, face-to-face visits were cancelled and work was delayed until October 2020. Over the span of eight months, sixty 9th grade students worked in half groups to study olive oil. They connected with local experts to consider big questions around how olive oil is produced, the growth of olive trees, the soil, and industrial processes to manufacture olive oil at scale. These investigations led students to imagine future techniques and more sustainable models for creating olive oil while maintaining their cultural heritage.

Real ideas, authentic problems, Democratizing knowledge, Improvable ideas, Rise above
After learning the basic features of Knowledge Forum (e.g., notes, build-on notes, epistemic markers) in September, students spent the next month discussing what they wanted to know about the olive oil: collecting olives, olive oil factories, quantity of tons, countries that produce olive oil, olive trees, soil, olive tree diseases, exportation of the olive oil, etc. The students selected a Youtube video about how olive oil is made. In November, students interviewed two olive oil producers (Mr. Fèlix Güell and Mr. Pau Grau) which opened up a new question for understanding: "Why do olive trees produce a lot of olives one year and only half the following year?". Students discussed their theories before reaching out to a geneticist to learn more about olive shapes, olive tree diseases, soil and climate arose in their minds. By December, students integrated ideas and theories into rise above notes and identified additional promising areas of work, like how genetics could improve olive harvest, how we can engineer more resilient olive trees and the role that soil plays in growing healthy olive trees. They then wrote to a geneticist requesting an interview.

Epistemic agency, Constructive use of authoritative sources, Pervasive Knowledge Building, Rise above
In January, students contacted a researcher in Cologne (Enric Bertran García de Olalla) to exchange ideas and advanced collective understanding around the role that genetics plays in the shape of olives, olive tree diseases, and bioengineering techniques to improve olive trees. Over the next two months, students continued working on Knowledge Forum until they achieved a deeper understanding and felt ready to share their new learnings. Figure 4 shows the video that students created and disseminated their Knowledge Building process and conceptual advances on Youtube. During the final two months of the school year, students consulted additional authoritative sources online and found some interesting facts about olive tree genoma, better olive trees, and the shape of the olives. Their culminating rise aboves notes included design ideas, such as "better olive oil factories" and a "healthier olive oil". As their next step, students wanted to make deeper connections with ecology and human health for further investigations.

Figure 4. Students connecting with local experts to learn about olive oil

Preliminary Analyses

Knowledge Building discourse, Community knowledge
All in all, students spent 110 hours studying olive oil and contributed 199 notes and 11 rise above notes. Figure 5a) shows their Knowledge Forum view and Figure 5b) shows the distribution of their scaffold use over the course of eight months. As can be seen in Figure 5, The most commonly used scaffolds were *"New information"*, *"My theory"*, and *"Putting our knowledge together"*, suggesting that students were engaged in contributing their ideas, searching for new ideas in authoritative sources, and synthesizing the diverse range of perspectives presented on Knowledge Forum. The least commonly used scaffolds were *"I need to understand"*, *"This theory cannot explain"*, and *"A better theory"*, suggesting that students did not actively critique each other's ideas. In future iterations, we are considering how we can foster a culture where students feel safe to take risks with ideas and critique theories in a polite and respectful manner. Additionally, we are considering how the scaffolds can be used to support idea improvement. Elsewhere, teachers have worked with students to customize scaffolds to deepen their Knowledge Building discourse (Ma, Martin, & Akyea, 2020).

a) b)

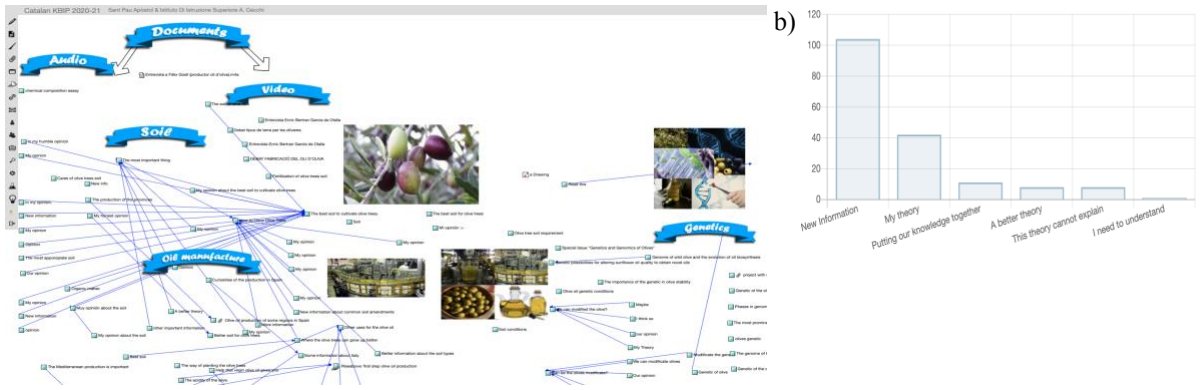

Figure 5. Knowledge Forum a) view on olive oil and b) scaffold growth assessment (Oct-May).

Teacher/Researcher Reflections

It was most remarkable that students were fully engaged with the topic of olive oil throughout the entire school year. While were some times where the teacher had to provide emotional support because the students felt alone in their research, social interactions with experts, group reflections and discussions were really effective at reigniting students' motivation. The students were eager to use the experts' ideas to generate more powerful and fruitful theories, which in turn helped them imagine new ideas and new ways of thinking. At the end of the year, the students felt a sense of accomplishment and pride in their collective work. Students were also excited to prepare documents, videos, photos, illustrations and interviews for dissemination in the April Knowledge Building International Newsletter because it made them feel like their ideas were valuable, and they were part of a larger community, actively contributing knowledge for public good.

Below are a few additional reflections from the teacher on how his practice can be improved:

- Deepening norms of engagement: Encourage students to read all the notes to know the whole feeling that is "hidden" inside the notes. Explore co-authorship features to support students in writing group summaries as work progresses.
- Spending more time on reflection: After reading all the notes, give students dedicated time to think and develop ideas, test out their ideas, propose different ones, make new connections, etc.
- Designing different scaffolds to build on notes: Integrate KF time during class discussions so that build-on notes can be added in real-time, with new scaffolds co-designed with students to identify next steps.
- Maintaining a list of partners: Students benefited from interacting with experts, so more opportunities for cross-community engagement could help sustain collaborative work.
- Empowering action and change: Students feel they are too young to change the world. Additional supports are needed to help them translate their ideas to action (e.g., connecting with local organizations to raise awareness about issues).

Year 2: Designs for Connecting with Global Expertise

Cross-Community Collaboration

In anticipation for cross-community collaboration between Ontario and Tarragona in the upcoming school year, additional analyses are underway to explore areas of intersect between the primary and secondary science curricula. For example, the grade 2 discourse on salmon restoration and the grade 9 discourse on olive oil and soil both have implications for climate change and simultaneously advancing UN goals of life on water, life on land, climate action, sustainable cities/communities, and responsible consumption/production. Students have already identified broader connections between ecology, genetics, and human health – how can we build on these advances to sustain knowledge advancement?

An added challenge identified by teachers is how to foster a sense of community knowledge, collective responsibility with diverse students spread out across the globe. Past work points to the value of creating new views in Knowledge Forum dedicated to facilitating cross-cultural exchange between students so that they may create a sense of community through finding common experiences, as well as celebrating the differences of individuals coming

from diverse backgrounds (Ma, Martin, & Berrones, 2020). For example, while Christmas is a holiday celebrated around the world, different cultures have developed different traditions to observe this holiday. Conversations with global partners on Knowledge Forum provided students with intimate knowledge of local practices and artifacts that they would not otherwise find on Google. To further this, these cross-cultural views also provided a safe space for students to find peer support during the emergency lockdown that resulted from the global pandemic. Used in this way, students were able to develop empathy and perspective-taking skills through discussions of each others' experiences during the pandemic while offering socio-emotional support and comfort.

To address the sustainability of cross-community collaborations and cross-cultural exchanges, we are proposing a global metaspace design that can allow students to easily share their thoughts as epistemic artifacts via multimedia representations, such as video narratives describing and/or synthesizing their experiences, breakthroughs, and challenges in a way that can be readily accessible to members of other communities around the world. Figure 8a) shows how local communities can come together in the global metaspace to create a network of networks, with Figure 8b) showing the movement patterns of different communities engaging with the global metaspace, orbiting different communities as work proceeds, and returning to the global metaspace as a touchpoint to exchange ideas, tools, resources, data, and expertise. The ultimate goal is to provide affordances for sustaining idea development within and across communities through visualizations of knowledge growth at various scales.

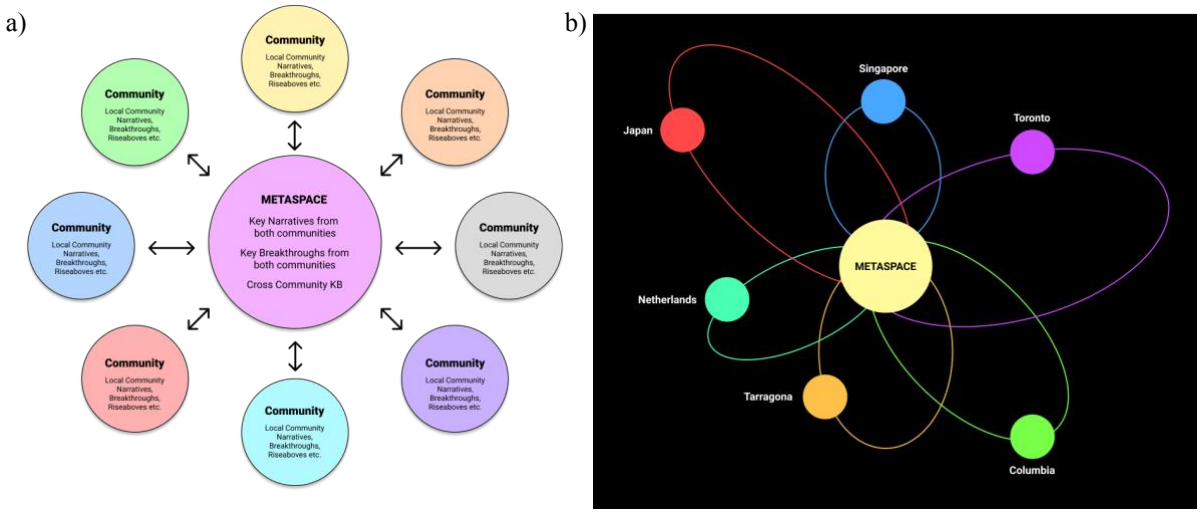

Figure 8. Metaspace mockup a) local and global relationship b) potential intersections of local communities

Implications for Metaspace Designs

Historically, common barriers to symmetric knowledge advancement between Knowledge Building communities in schools include (but are not limited to): age, time, curriculum, assessment, geography, technology infrastructure, human capital, outdated beliefs about knowledge and expertise, and so on. It should be noted that expert communities also face such challenges but have had access to resources and inter-organizational supports to overcome these challenges in ways that sustain knowledge advancement. Thus, the primary aim of the Knowledge Building metaspace is to remove barriers to cross-community collaboration and close the gap between schoolwork and knowledge work in the world, with the long-term aim of repositioning schools as centres of innovation.

The Knowledge Building metaspace also aims to serve as a global design space for Knowledge Builders of all ages located anywhere in the world to contribute ideas to help advance the vision of education for knowledge creation. In addition to providing affordances for housing epistemic artifacts, new tools will provide multiple entry points for participants to engage with ideas, new assessments will help communities forge new frontiers together, and new features will make access to a network of global expertise become as convenient as possible.

As an extension of Zhang and colleagues' (2017; 2018; 2020) work on cross-community collaboration, we propose a design prototype that integrates networks of idea threads across multiple communities. Figure 9a shows the Idea Thread Mapper (Chen & Zhang, 2016) along a two-dimensional space, with the x-axis representing time and the y-axis representing the conceptual threads in the student discourse. In Figure 9b, we propose a multi-dimensional space that "folds in" idea threads from different communities, including open-access resources created by experts easily retrieved from the Internet. For example, each cross-section of the mandala can represent a different Knowledge Building community across the grades, as well as curriculum documents, policy documents, historical archives, data

repositories, Google Scholar libraries, etc. Participants can zoom into a specific slice of the mandala to examine local idea threads in depth, as well as zoom out to explore connections between global communities.

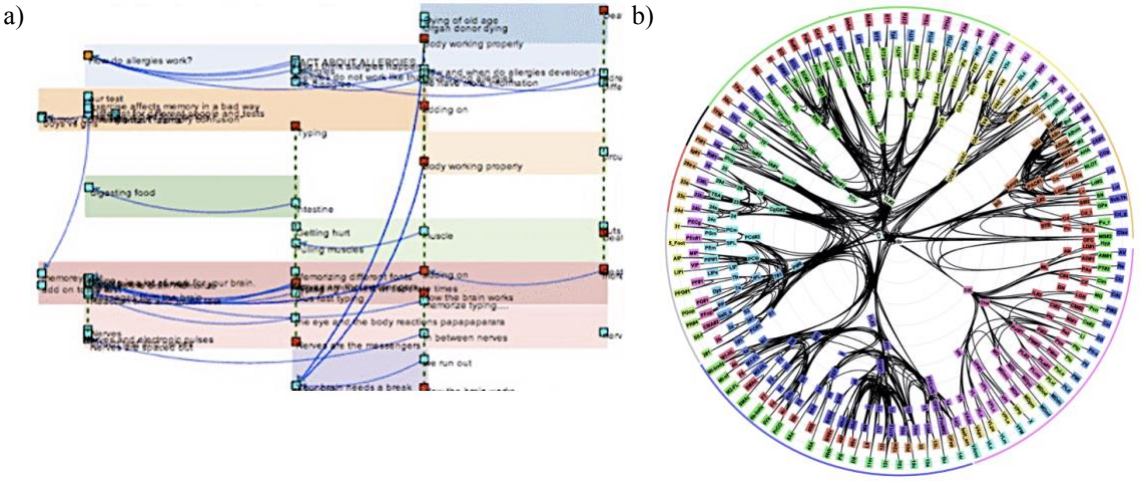

Figure 9. Visualizations of idea threads in a) a two-dimensional space and b) multi-dimensional space across multiple communities

For the classroom teacher, each Knowledge Building community will be able to design their own view, which will be added as a new cross-section to the mandala, once they decide to publish to the global community. In this public-facing view, students would document the evolution of thought in their community, bringing to light the highs and lows of their learning journey via digital storytelling using various multimedia. These key narratives will serve as invitations to members of the global community to explore their breakthroughs, build on with new questions and resources, and help identify common areas that need further work. Embedded analytics will identify points of intersect between challenges, successes, and key learnings across communities to facilitate this process, with new tools being developed to recommend serendipitous or "unlikely" partnerships. Recall that deliberate, sustained efforts are required to re-distribute expertise within and across communities, therefore the challenge posed by the Knowledge Building metaspace is a social one as much as it is a technological one.

The following are key issues raised to advance principles-based design of a metaspace for the global design experiment. We expect to further elaborate these issues through audience engagement with the panel discussion to rise above tensions between local and global constraints of cross-community collaboration:

- *Community knowledge, collective responsibility:* How can the metaspace help teachers and students see their work as part of civilization-wide efforts to advance knowledge for public good? What would norms of engagement around participant interactions and idea interactions in a global network of networks look like? (see Hong et al., 2010 for examples)
- *Democratizing knowledge, Knowledge Building discourse:* How can epistemic scaffolds be designed and refined to support idea improvement and deeper engagement with ideas in the global community? How can we go beyond traditional models of cross-cultural interactions between nations and knowledge dissemination between experts and novices? (see Lu & Ma, in press for examples)
- *Epistemic agency, Idea diversity*: How can teachers and students find global partners with different epistemological orientations to advance knowledge for public good? How can more direct links be made between conceptual advances and equity-oriented outcomes to inform the systematic implementation of real-world change in varied contexts?
- *Real ideas, authentic problems, Idea improvement:* How can we support teachers and students in identifying problems at the cutting edge of understanding? For example, the UN Sustainable Development Goals (https://www.un.org/sustainabledevelopment/) has served as a framework for engaging students in global citizenship, however, this framework fails to convey complexity and entanglement of wicked problems in our societies.
- *Constructive use of authoritative sources*: How can different types of expertise be conveyed in ways that depart from hierarchical notions of knowledge? How can we position Knowledge Building

communities at all stages of progressive knowledge work in the metaspace to highlight synergies and opportunities for sustained innovations?

- *Symmetric knowledge advancement:* What types of social and technological affordances would support simultaneous advancement of knowledge in local and global contexts? How can timely communication and feedback between different timezones be designed to facilitate coordination and refinement of solutions across local contexts?
- *Embedded, transformative assessment:* How can automated assessment tools be used to support participants in creating/remixing video narratives of knowledge advances to contribute to the metaspace? How can affordances of the semantic web (e.g., knowledge-creating analytics) be used to investigate emergent idea trajectories and help people explore and interact with networks of ideas across initiatives?
- *Rise above:* How can the complexity of Knowledge Building be conveyed in an accessible way to participants in the metaspace? What type of social and technological affordances would be needed to represent conceptual coherence across disciplines, sectors, and nations, as well as tensions that point to conceptual areas in need of further knowledge advancement?

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The Evolution of Creative Drama in Elementary Students' Reading Based on Knowledge Building

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Abstract: Creative drama was generated and evolved in the reading of "Journey to the West" in a grade 4 Knowledge Building community of China. This paper tracked the teaching process for 9 months and collected various artifacts, such as mind maps, scripts, rehearsals, performance, reflection and so on. The creative drama process was divided into four phases: independent reading, theme inquiry, performance and drama theories building. In the process, a large number of artifacts are produced, such as posters, mind mappers, scripts, reflective diaries and so on. The results show that: The students' inquiry unfolds radially; the scripts reflect a certain degree of creativity; the creative drama produces the theories about scripts, actors and performance; the theory system are finally built based on the students' reflections.

Introduction

Due to the function of developing students' comprehensive ability, drama has entered the field of education. Drama education formed the theory system in the early 20th century in western countries, and then developed into drama in education, education drama, creative drama, theater education, development drama, therapeutic drama and other forms. Drama in education rose in China in the late 20th century. Creative drama can inspire students to think, and guide them to improvise. At present, creative drama begin to integrate with Chinese, morality, and foreign language (Davis & Behm, 1978).

As one mode of knowledge creation metaphor, Knowledge Building (KB) is an idea-centered, principle-based theory (Scardamalia, 2002). It aims to promote students' idea improvement through continuous discourses, and to form community knowledge (Hong & Sullivan, 2009). Can Knowledge Building be applied to creative drama instruction? This study focuses on the two research questions: (1) How does the creative drama develop in the Knowledge Building instruction? (2) Can Knowledge Building improve students' creative drama? To solve the problems, this study tracks the creative drama process of the primary school students in "Journey to the West" in Knowledge Building community.

Literature Review

Creative Drama

The Children's Theatre Association of America (CTAA, 1977) defines creative drama as a kind of impromptu, non-performing and process-centered form of drama. Creative drama attaches great importance to children's participation and creativity in the performance process. Dewey (1934) believes that exploring games and plays can stimulate children's creativity. Ward (1947) regards creative drama as a kind of self-expression of children, and the process of "drama making" is more important than the performance. Further more, Siks (1977) focuses on the participation process of teachers and children in drama. The perspective of "Whole Child" (Bueger,) under the "Total Growth" is gradually recognized, and McCaslin (2006) summaries the evolution of educational objectives from

“Reading, Writing and Arithmetic” to creativity, critical thinking and social interaction. Existing studies have shown that creative drama plays a positive role in promoting children’s participation, cooperation, creativity (Lehtonen, et al., 2016) and higher-order thinking (Sacli, et al., 2012) and so on.

Knowledge Building

Beyond the metaphor of acquisition and participation, knowledge creation not only focuses on the knowledge acquisition of individuals, but also on the artifacts generated in the discourses and the formation of community knowledge (Paavola, Hakkarainen, 2005). As one mode of knowledge creation metaphor, Knowledge Building pays attention to the continuous idea improvement and the generation of community knowledge, knowledge exists in Popper’s world 3 (Bereier, 2002). Scardamalia (2002) puts forward 12 principles of teaching. They are consistent with creative drama, for example, students posed various ideas: “why does the monkey king have divine power as soon as he was born?”, “why does the Monkey King have 72 changes?”, “Why Tang monk was not eaten immediately after he was captured by the the monster?”. Some students thought Pigsy was gluttonous, while others thought he could adjust the atmosphere.

Methods

Participants and Context

The participants in the study were 37 primary school students of a grade 4 class about 9-10 years old with 20 girls and 18 boys, from the Xinjiang Uygur Autonomous Region of China. They experienced Knowledge Building instruction for the first time. They were active and interested in reading and performing. The teacher was an expert teacher with 10-year teaching experience, and was interested in Knowledge Building very much.

As one of the four classic Chinese masterpieces, Journey to the West is a mythological novel, written more than 400 years ago in the Qing Dynasty. It mainly describes the birth of a stone monkey, Monkey King, a household name. After he caused havoc in heaven, he met Tang Priest, Pigsy, and Sha Monk, and went west to learn the scriptures. Along the way, they went through hardships and dangers, subdued various demons. The master and disciples overcame 81 obstacles, finally reached the west heaven to meet the Buddha and obtained the true scriptures.

Pedagogical Design

Knowledge Building was adapted in the creative drama of Journey to the West, lasting for more than one semester, about 9 months. The instruction was designed for the reading of Journey to the West, while the students spontaneously became interested in the performance. The teacher seized the opportunity timely to encourage the students to write scripts, and the students rehearse by themselves. So the creative drama is a by-product in the instruction. That is to say creative drama is gradually generated and evolved in the process of reading.

The creative drama process was divided into four phases which reflected the generation and evolution of creative drama. They write their ideas on notebooks or on KF so as to communicate with their classmates.

Phase I independent reading: Students read the novel independently and posed their real questions of their interest, and Knowledge Building provides various scaffolds to encourage students to put forward a large number of ideas, such as “I like”, “what I have known”, “My evidence”, “I want to know” and so on. For example, I want to know why the monkey king has 72 changes? I want to know why the monster didn't eat Tang Monk immediately after he was captured? I want to know why the

Monkey King is born with magic power? I want to know Where the Monkey King come from? I want to know how many things the monkey king has solved? I want to know how many countries the master and apprentices passed by. Based on their own real questions, students discuss on the platform

Phase II theme inquiry: Students read the notes with each other and different ideas are connected to evolve into new and more refined forms. On the other hand, it is also a warm-up action for students to carry out creative drama. Students with the same interest formed a group for further inquiry and themes are formed.

Phase III performance: They watched films and television to improve their ideas with constructive use of authoritative data. Then they wrote scripts, rehearsed and performed themselves. Each student wrote a script according to Journey to the West and the themes can be divided into several categories, plot reappearance, rearrangement, continuation, and time-travel drama. At last four scripts were voted. The groups were reorganized and the four scripts were revised: Borrow palm fan for three times, science and technology during the pilgrimage for Buddhist scriptures, hit White Bone Demon thrice, transcending time and space.

Phase IV drama theories building: They wrote reflection and summaries to build theories of creative drama, such as how to write a script, how to be a good actor.

Data sources

Data were collected from students' artifacts, including posters, scripts, reflective diaries and notes on the Knowledge Forum (see Table 1). Data are analyzed mainly with content analysis method.

Table 1: Artifacts

Items	Number
Mind mappers	29
Paintings	20
Posters	15
Scripts	4, about 7000 words
Performance video	4, about20 minutes
Reflections	37, about8000 words
Notes on KF	334 notes

Students expressed their ideas on KF. There are 1724 connections between ideas, 1472 times of reading and 148 comments. The network density is 0.11.

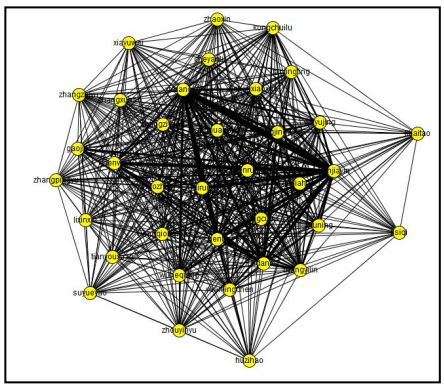

Figure 1. Social Networks.

Results

The evolution of creative drama has experienced four phases and a large number of artifacts are produced, which reflects the continuous improvement of ideas in the KB community.

Reading

At first, the students read the Journey to the West independently and make reading records. They are mainly interested in the chief characters, four masters and apprentices and their weapons, such as golden cudgel, nine-tooth rake, nine ring stick. With further study, they gradually become interested in fairies and monsters, including the fairies' magic power, magic weapon and stories, as well as monsters' characteristics, weapons, masters and fate. More than 20 kinds of weapons are explored. After this kind of radiation reading, students form the reading perspective of multiple and network angles. The students' understanding of Journey to the West unfolds radially, from the four master and apprentices to their weapons, then to the fairies and monsters and their weapons, as well as the countries, routes and food on the journey (see in Table2).

Table 2: Inquiry Topic.

	Characters	Immortals	Monsters	Weapons
No. 1	Monkey King	Tathagata Buddha	White Bone Demon	Iron-toothed rake
No. 2	Pigsy	Avalokitesvara	Ox demon king	Nine ring tin stick
No. 3	Tang Monk	Lord Lao Zi	Black bear essence	Golden cudgel
No. 4	Iron Fan Princess	Jade Emperor	Golden horn silver horn King	Yujing bottle
No. 5	Red boy	the Queen Mother of the West	Scorpion essence	Purple gourd

Students put forward some simple or absolute ideas at the beginning, such as "I like the Monkey King", "I want to study the golden cudgel" or "I hate Pigsy". The impression of Pigsy is gluttonous, lustful and easy to escape. Students like or hate somebody or something absolutely. With the deepening of the reading, students can see the characters from both positive and negative aspects, for example, students also see Pigsy' advantages of "gentle, loyal to the master, and be good at adjusting the atmosphere" except his shortcomings. Students have learned to treat people and things dialectically. To further improve their understanding, students use authoritative materials to prove their ideas, such as books, films, television, network information and so on. On this basis, they summarize the personality characteristics of the four mentors, compare their advantages and disadvantages, and analyze the suitable positions from the team cooperation. Many students put forward that it would be meaningless without weapons and without monsters. To some extant, the monster help the master and apprentice overcome the 81 difficulties and obtain the scripture.

Figure 2. Weapon research

Scripts

In the process of collaborative learning, some students always like to imitate the characters in the novel to speak and act. They pick up a wooden stick as a golden cudgel, and said that “Monsters, where to run?” The teacher seizes the opportunity timely to encourage the students to write scripts and act. They can adapt, renew and create the original works. Each student writes a script and voted the more satisfactory ones. At last four scripts are voted and their authors become the directors. In order to better improve the scripts, the groups are reorganized and the four scripts are revised again and again. The final scripts are: Borrow palm fan for three times, science and technology during the pilgrimage for Buddhist scriptures, hitting White Bone Demon thrice, transcending time and space. Those can be divided into three types: plot reappearance, pass through type, and follow-up. The scripts highlights the conflicts of the script, attractive plot, ups and downs, which reflect a certain degree of creativity.

Table 3: The final scripts

Scripts Name	**Type**	**Number of actors**	**Time**
Borrow palm fan for three times	plot reappearance	6 students	4.5min
Science and technology during the pilgrimage for Buddhist scriptures	follow-up	11 students	2.5min
Hitting White Bone Demon thrice	plot reappearance	7 students	7min
Transcending time and space	pass through	7 students	4min

Performance

Students write, direct and play creative drama by themselves. The directors select actors, the members prepare props, such as clothes, weapons, head accessories and so on. They rehearses and performs on the playground themselves. Students evaluate each works, point out the advantages and disadvantages, and put forward suggestions for improvement. Even if the teachers go on business for a few days, they still rehearse by themselves. When the teachers come back, they can perform.

Educational drama is different from professional drama performance. It focuses on dynamic process, cooperation and problem-solving in the real situation. The understanding of drama theories helps to enhance the appreciation of drama (Siks, 1977), for example, how to write a script and how actors perform. Some students criticize the position of the actors in the rehearsal process, he should stand in the middle of the stage but not in the corner. The actor who played the Pigsy was questioned because he was still laughing when he was about to be eaten by a monster, and he was suggested to show sadness and panic. When the theme of a group is not prominent enough and the actors are not clear about the purpose of the performance, the classmates point out the essentials and precautions of the script writing. A consensus was reached that everyone should be a good playwright first and then an actor. The theory system of this creative drama includes scripts, actors and performance.

Drama Theories

Knowledge Building not only emphasizes diverse ideas, but also the summaries of higher-level ideas. So theory building is essential in Knowledge Building community, rather than just staying at the level of performance or activity. Disordered and trivial ideas should rise above to systematic theories. Taking “Journey to the West in my eyes” as the topic, students write their summaries. The theory system of characters, weapons and monsters has been formed.

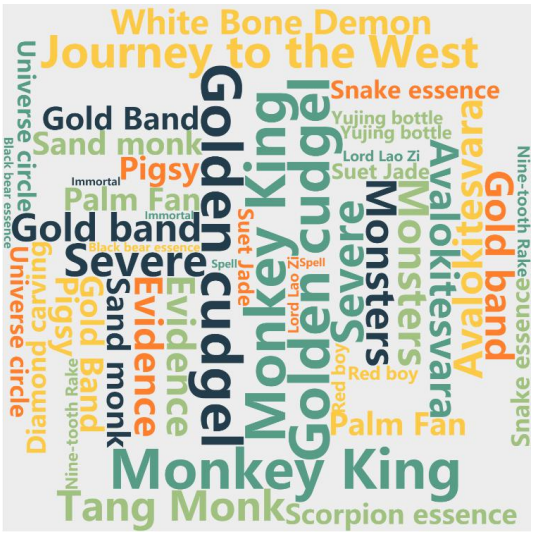

Figure 4 The word cloud of the reflection

Implications

The main characteristic of creative drama in Knowledge Building environment is generative. Creative drama in this study is spontaneous and independent, including theme, script, role, performance and so on. The creative drama experiences several transformations, from fun to performance, from reading to embodied cognition, from spontaneity to evolution and theoretical construction, which reflects the idea improvement and knowledge creation of KB. The innovative teaching methods is gradually generated and evolved in the process (Hong, et al., 2016), which is different from the procedure-based teaching. The transformation from the participation metaphor to the knowledge creation metaphor has been realized.

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Extending the Psychological Infrastructure of Knowledge Building Communities

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Abstract: Knowledge building communities are fundamentally organized around a set of twelve idea-centered principles. In recent years, increasing attention has been paid by the knowledge building community to extend the psychological principles needed to support knowledge building. With an eye on contributing new ideas that can help solve this challenge, in this research we review mindset theory, person-centeredness, and positive education as three theoretical perspectives that can help inform and articulate new psychological knowledge building infrastructure principles. We suggest several activities as embodiments of these principles in practice. Building on these tentative ideas, we suggest a research plan that has the goal of articulating the psychological dimensions needed to foster knowledge building.

Keywords: KBCs, infrastructure, design principles, psychological infrastructure

Introduction

Knowledge Building Communities (KBCs) are one of the most well-known and influential educational models seeking to foster a culture of creativity, collaboration, and innovation in classrooms (Chan & van Aalst, 2018). Developed by Scardamalia and Bereiter three decades ago, KBCs have since become the longest serving design experiment in education (Bereiter, 2006), with a large international research and practice community and hundreds of published empirical studies. KBCs are fundamentally organized around a set of twelve idea-centered principles which are written so that practitioners can interpret and implement the most relevant and situationally-sensitive practices in their classroom without losing sight of the knowledge building goals (Scardamalia, 2002; Zhang, Hong, Scardamalia, Teo, & Morley, 2011). These principles have been modified and elaborated in several studies (e.g., van Aalst & Chan, 2007), and even Bereiter himself concedes that they are somewhat arbitrary (1), but nevertheless they have endured (Chen & Hong, 2016).

In recent years, increasing attention has been paid by the KB community to extend the non-idea-centered infrastructure needed to support knowledge building. For example, some knowledge building researchers have examined how students' mindsets may play an important role in their successful participation in the knowledge building process (Kashi & Hod, 2020; Kici & Scardamalia, 2018), while others have examined emotional issues (Hod & Katz, 2020; Zheng, Zhong, & Niu, 2021). Some authors have directly suggested that a social infrastructure is needed (Bielaczyc, 2006) beyond the many ongoing efforts at developing the technological infrastructure (Chen, Chang & Groos, 2020; Oshima, Oshima & Matsuzawa, 2012; Zhang et al., 2018). While knowledge building principles may accurately articulate knowledge building processes, certainly students' emotional, social, and personal lives are relevant and need to be attended to within any implementation. One of the current challenges for the knowledge building community is to more fully understand what principles underlie this infrastructure and how it supports knowledge building (Cohen & Hod, 2021).

With an eye on contributing new ideas that can help solve this challenge, the goal of this research is to articulate the psychological dimensions needed to foster knowledge building. In the following sections, we give a brief overview of KBCs and their principles so that it will be possible to distinguish between knowledge building, per se, and the infrastructure needed to support it. After that, we summarize existing efforts to articulate this infrastructure, even if an infrastructure framework was not part of the researchers' framework explicitly. Third, we review relevant ideas from other fields that can inform what a psychological infrastructure for knowledge building may look like as a basis for an empirical research project that we plan to carry out to instantiate these claims.

Extending the Psychological Infrastructure for KBCs

KBCSs – formerly known as Computer-Support for Intentional Learning Environment (CSILE: Scardamalia & Bereiter, 1994) – were introduced by Scardamalia and Bereiter as a theoretical and pedagogical framework in the early 1990's. KBCs were heavily influenced by the ideas of authenticity and enculturation. Following this logic, KBCs are designed to approximate the culture of authentic knowledge building organizations and their practices within

classroom contexts (Hod & Sagy, 2019; Scardamalia & Bereiter, 1994). While some pedagogies invest in polishing the procedures provided to educators to create easy-to-follow rules, KBCs take a principle based approach (Scardamalia, 2002; Zhang et al., 2011), providing educators with a set of principles to aim for, leaving them room for situated interpretations and adjustments.

Twelve principles underlying the KBC approach have been articulated in various formats over the years (Chan & van Aalst, 2018; Chen & Hong, 2016; Cohen & Hod, 2021; Scardamalia, 2002; Zhang et al, 2011) with some modifications, such as van Aalst and Chan (2007) who condensed them into five principles to help students understand and work with them. While the principles have remained durable despite implementations in diverse settings (Cohen & Hod, 2021), there have been increasing efforts in recent years to investigate the infrastructure needed to foster KBCs in classrooms. Still, these efforts have not systematically explored how their findings can be used to supplement or extend the current set of KB principles. The long-term process of revising design principles with new innovations – what has been called an informing cycle (Puntambekar, 2018) – should be at the heart of the knowledge building endeavor around KBCs. In this section, we explore how mindset theory, humanistic psychology, and positive psychology may contribute to extending the psychological infrastructure for knowledge building.

Mindset Theory

The core of mindset theory is based on people's implicit beliefs about intelligence as being a fixed or malleable trait and its relation to learning orientations (Dweck, 2006). People with fixed mindsets tend to perceive abilities and talents as proving they are intelligent, and therefore are more likely to pass up opportunities to push their limits or deal with challenges because failures come with the risk of jeopardizing their attributed intelligence. In contrast, people with growth mindsets attribute their failure to poor strategies or effort which they can constantly improve, therefore making them more likely to embrace challenges and see them as opportunities of growth, progress, and the development of skills. Dweck's conceptualization of learners' fixed and growth mindsets have been widely published and have become very influential across educational research and in organizations seeking to promote their employees' growth mindsets.

The popularity of the mindset approach has resulted in misconceptions about how to implement it. Fostering a growth mindset is not just about praising effort and should not be reduced to teacher-student interactions (Dweck, 2015). Rather, mindset researchers have claimed that cultivating a growth mindset requires fostering a classroom culture that supports long-term growth (Dweck & Yeager, 2019). Students, for example, should be given constant feedback by teachers and peers so that they can continuously assess their own progress (Haimovitz & Dweck, 2017).

There has been some recent research in the context of KBCs to explore growth mindsets (Hod, Zhang, Yuan, & Zhou, 2018; Kashi & Hod, 2020; Kici & Scardamalia, 2018) While these studies were preliminary, only being published in conference proceedings, they attest to the new interest in this area based on the rationale that mindsets may support students' identities as knowledge builders. A knowledge building infrastructure principle that may stem from these efforts could be articulated along the lines of the following: *Foster growth mindsets by encouraging community discourse to focus on the challenges or obstacles faced when engaging in knowledge building, and include opportunities for participants to reflect and intentionally refine their practices*.

Humanistic Psychology

While mindset theory emphasizes fixedness and growth by means of one's beliefs regarding intelligence, there are other theoretical approaches that have addressed fixedness and fluidity by taking into consideration other facets of human learning. Specifically, Carl Rogers' person-centered approach upended psychoanalysis in the mid-20th century by proposing that the agency to improve or grow belonged with the client instead of the therapist. In his famous book, *Freedom to Learn* (Rogers, 1969), Rogers applied this approach to education, which he claimed was highly relevant to all people. In describing the process of change when the right conditions (a growth-promoting culture) were evident, Rogers (1961/1995) described multiple dimensions in which a person can shift between fixedness and fluidity. The first stage is full fixity, where a person does not acknowledge having any problems and opposes change. Moving along this continuum, a person gradually accepts self-responsibility to face problems, recognizes personal rigidness, and expresses feelings. By the highest stage, people reach a point where they are open to experience and where spontaneous growth can occur (Rogers, 1961/1995). The conditions that Rogers described to foster these changes involve providing unconditional acceptance, empathic listening, and congruence so that students can feel safe enough to reveal and explore their feelings and thoughts. This person-centered approach fosters the development of students' growth-oriented identities (Cornelius-White & Harbaugh, 2010).

Hod and Ben-Zvi (2014, 2018) introduced a humanistic perspective based on Rogers' approach to KBCs, which has been the basis of an ongoing research effort. In a relatively recent study, Hod and Katz (2020) found that the three person-centered conditions played a significant role in fostering close relationships among community

members and, consequently, the depth of knowledge building chains. In other research, Kashi and Hod (2020) used a grounded approach to discover a five-category model with the dimensions of fixedness and fluidity. Generally, the first level – fixedness – included expressions that insinuated resistance or avoidance towards change. The second level – steps towards growth – included expressions that showed recognition of the need and desire to change. The third level – growth – included acting on and actively exploring change. The data collected showed the growth of a KBC in a graduate course (primarily composed of teachers studying educational technologies) by tracing all of the different students' utterances throughout the semester. Ultimately, these data showed how the KBC on the whole transformed to take a growth orientation.

Drawing on this emerging body of work, we suggest that the following person-centered principle could be part of the psychological design infrastructure for knowledge building: *support personal fluidity by establishing norms where community members provide unconditional positive regard to one another, actively and empathically listen, and communicate their thoughts and feelings in ways that are congruent with their own experiencing of the world*.

Positive Education

Positive psychology – and its derivative positive education – has become very popular in recent decades as an outgrowth of the humanistic psychological movement (Gable & Haidt, 2005). In contrast to the orientation of traditional psychology to treat people's pathologies or foibles, positive psychology focuses on their strengths and the conditions that can contribute to flourishing, wellbeing, and quality of life (Seligman & Csikszentmihalyi , 2014). Building on principles underlying positive psychology, positive education combines education for traditional skills and wellbeing which broadens students' attention, nurtures creative and holistic thinking, and ultimately results in learning gains (Seligman et al., 2009).

Translating positive education into the context of KBCs has been the subject of recent research. For example, Ma, Resendes, Scardamalia, and Dobbie (2019) created a multi-district KB network that connected principals, vice-principals, and teachers in Ontario, Canada, to support KBC implementations. The authors made a point of the promising results suggesting that these efforts ultimately led to greater student learning and well-being. This relation between knowledge building and well-being, one of the key goals of positive education, has been documented by Scardamalia and Bereiter (2017, p. 78): "In our experience students' well-being is associated with their feeling of belonging to the community through contributing ideas that grow." In short, research on KBCs suggests that well-being and knowledge building may be closely associated with one another, and future research can better articulate the mechanisms underlying this connection. We therefore suggest that an infrastructure design principle based on positive education could be the following: *Fostering well-being by having communities recognize the uniqueness of all its diverse participants, make efforts to ensure they belong, and provide them with a mindful climate where they can safely explore their strengths*.

Embodying Psychological Principles into the Design of KBCs

Humanistic Knowledge Building Communities

In recent years, the Humanistic Knowledge Building Community (HKBC) model was developed, in part to embody psychological knowledge building infrastructure principles in classrooms designed as KBCs. HKBCs draw on the theories introduced in the previous section, all of which emphasize fluidity and growth. The "H" in HKBCs refers to what the authors referred to as humanistic activities (Hod & Ben-Zvi, 2018) designed to foster a growth promoting culture. This includes norms where unconditional positive regard to others, empathic listening, and being congruent in relationships are present (Rogers, 1989). Humanistic activities provide the community with the opportunity to face authentic challenges and publicly reflect on them as they work towards mastery (Hod, Basil-Shachar & Sagy, 2018). Legitimizing discourse about setbacks and difficulties in the process (Haimovitz & Dweck, 2017) encourages individual and collective growth. Likewise, the humanistic activities favor choice-based assessments focused on persistence and growth rather than on knowledge (Schwartz & Arena, 2013).

Our view in this paper is that the H in HKBCs is largely informed by psychological knowledge building infrastructure. Of course, this infrastructure overlaps with other dimensions of infrastructure (e.g., social, technological, etc.), but given that they are grounded in psychological theories, we distinguish them accordingly. We believe that the title of HKBCs may be misleading in that it suggests that they are fundamentally different from KBCs. In some ways this is the case, as the humanistic purpose is not necessarily inferior to the knowledge building efforts. Still, insofar that the goal of an implementation is to advance knowledge, the H can be seen as a secondary purpose meant to support the primary goal of knowledge creation. To avoid this confusion, we therefore suggest framing this as KBCs with psychological infrastructure.

Activities that Embody Knowledge Building Psychological Infrastructure

The three psychological approaches described above (mindset, person-centered, and positive education) suggest that psychological facets of learning play a crucial role in knowledge building endeavors. One of the key questions that is raised by considering these approaches has to do with how they can be embodied within classroom KBCs. We suggest the following activities, based on the psychological frameworks described above, as embodiments of knowledge building infrastructure. It is important to note that we do not suggest copying them from one setting to another, due to situational differences, however we hope this can give a more tangible idea of how these principles can be put into practice.

To build the psychological infrastructure for knowledge building, students need to get to know one another and feel comfortable and safe with each other, as well as engage in a continuous process of reflection and feedback about their identities as knowledge builders. Building a sense of safety takes time, and therefore activities geared for students to get to know one another should be frequent, throughout the duration of the community. Encouraging participants to "remove their masks" by revealing increasingly more details about their lives – including their strengths, weaknesses, personality, learning practices, etc. – allows students to express themselves more fully, which also fosters greater mutual understanding and empathy. For example, a student who often struggles to collaborate with others may easily be criticized by them. However, given the opportunity of others to get to know this person and their situation in life – which may legitimately inhibit their available time to advance knowledge – may help them empathize and act in ways that can facilitate their participation in their collective knowledge building efforts. Additionally, having participants (as individuals and groups) in the community reflect on their knowledge building efforts, and connecting these ideas to their identities as knowledge builders, can help the community be more intentional about the ways it functions. Thus, a reflective, meta-discourse is part of the psychological infrastructure, not only for the group to talk about how they build knowledge together, but for each person to understand how their own practices and identities form their approach to knowledge building. The continual process of learning about one another suggests that it is an endless process, consistent with the principle of idea improvement. There are numerous variations of activities meant to facilitate closer relationships and group cohesion, some of which are reported on in the following subsections.

Getting to know one another activities

In these activities, students are encouraged to reveal more about themselves and learn about others. These types of activities often open synchronous meetings (face-to-face or on Zoom) and last for about 20 minutes. Several examples include the following:

- *Carousel* - Students stand in two concentric circles, with the students in the inner circle facing outwards, and the students in the outer circle facing someone in the inner circle. Students are read a question to discuss, and after about five minutes of sharing one of the circles rotates and a new question is asked. Example questions include, "How do I feel right now? What am I most excited and nervous about with regards to our community? What did I bring with me today? What is something that most people do not know about me?"
- *Just listen* - Students are asked to pair up with someone that they do not know. Each student takes a turn listening to the other, without interrupting, for three minutes. After the speaker finishes, the listener must paraphrase what they heard and understood. The speaker and listener then exchange roles. Following these rounds, a whole group reflection focuses on eliciting what the students experienced being heard and paraphrased, as well as about the challenges of listening attentively.

Open group reflection sessions

Open group reflection sessions focus on the *here-and-now* of the group (Yalom & Leszcz, 2020). The here-and-now refers to what is going on, between the members of the community, in the actual moment. Thus, there is no set agenda by the moderator(s), aside from guiding the conversation to focus on the interpersonal relationships that exist in the group. One way of starting such a conversation is to ask the students to explore their interpersonal relationships in the group for roughly 15 minutes, with the moderator (and potentially one or two participant volunteers) watching from the side. After the time is over, they give their process commentary on what happened in the group, reflecting topics such as who is quiet and who talked a lot, whether the group was able to stay focused on task and why this was challenging, etc.

A variation on this activity is to ask students to share their experiences of knowledge building from recent activities. For example, in a community that meets once per week and continues online during the week, the focus of the open reflection session can be to ask a student to share their experiences. The guided moderation can openly explore what the student shares, with a focus on their feelings and the challenges that they face. In this sense, the focus is on the here-and-now even though material from the there-and-then is accessed. This offers a great opportunity to

discuss interpersonal issues that come up, such as what happens when students need to rely on one another or coordinate, or when they have to edit/advance another person's work.

Personal diaries on the KF

Students are asked to write personal reflective diaries on a weekly basis where they write about their experiences in the ongoing knowledge building endeavor (see figure 1). To facilitate this, students create and decorate a personal view on the Knowledge Forum, and each week post their public entry in the form of a note. A set of person-centered scaffolds guide these entries, such as "I feel that…" or "Something on my mind is....". Likewise, students are asked and encouraged to read others' entries and build-on them using scaffolds such as "I hear you saying that…" or "Your entry evokes in me…". This type of personal discourse helps ensure that students are seen and heard in the community (aided by the red and blue notes in the KF), giving students access to the feelings of others and facilitating the sharing of their own feelings and experiences, too. Likewise, this can help students get a more realistic appraisal of the way other students in the community see themselves, invaluable feedback that can help peripheral students take on more central roles in the community.

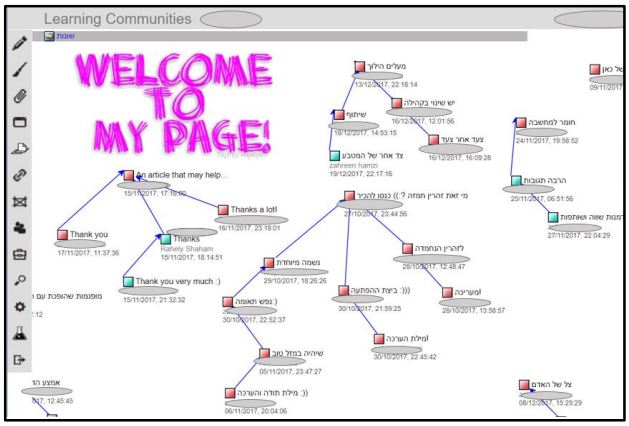

Figure 1. Example of a personal diary view created by a student in the Knowledge Forum

Community norms page

A community norms page on the KF provides opportunities for students to discuss their desired knowledge building norms. As new challenges arise, this forum gives students a space to discuss what is going on in the community at the moment as well as what norms they think ought to take shape in the community. For example, if an issue that challenges the community arises, such as the fact that some students are not taking epistemic agency, then the moderator (or based on participants' self-initiation, generally in more advanced groups) could suggest that the community engages in a discussion about being passive or active in the community. The norms page acts as a mirror to the community, by encouraging them to openly discuss their collective activity as it is, as well as to intentionally shape it based on their current interpretation and understanding of knowledge building. Thus, this is a live process that continually undergoes revision as the community evolves.

Planned Research

For the current research, we would like to extend this approach by measuring phenomena at the community level (Rogoff, 1995). This involves looking at the growth culture and practices as a unit of analysis. Furthermore, we plan to investigate kids in a subject area that is farther removed from the subject of learning and educational technologies. Specifically, we will be investigating middle school students studying history to better understand how belonging to a growth-promoting culture influences the knowledge advancements of their community. The main research goal seeks to advance our understanding of why, whether and how person-centered designs that are integrated with idea-centered designs contribute to the development of growth-promoting cultures. Moreover, we would like to measure how this approach may support collective knowledge building.

Conclusion

There are many reasons to believe, based on wide scholarship, that attending to the infrastructure of knowledge building can help the knowledge building process itself advance (Cornelius-White & Harbaugh, 2010). We believe

that the effort to widen and articulate knowledge building principles to those that are not necessarily idea-centered can have many positive consequences for fostering highly productive, sustainable KBCs at all levels. Articulating KBC infrastructure principles is not so trivial, as it requires finding ways to integrate them with the current set of principles. Yet, it also offers opportunities for new ways to think about existing knowledge building practices. For example, the KF has traditionally been an idea-centered tool, with features meant to support collective cognitive responsibility (Zhang, Scardamalia, Reeve, & Messina, 2009). We can envision, however, building new features into the tool to allow for some of the infrastructure principles to be embodied within the design of the KF. We believe that such efforts ultimately can help the implementation and success of KBCs, and we encourage a discussion around these set of ideas.

Endnotes

(1) https://www.isls.org/research-topics/knowledge-building/

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Examine the use of Knowledge Building in enhancing the effectiveness of Structured Academic Controversy in a Singapore Social Studies Classroom

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Abstract: This paper examines how effective Structured Academic Controversy (SAC) can be enacted in the Social Studies classroom using the Knowledge Building (KB) approach. SAC is a type of deliberation model that allows students to gain stronger understanding of societal issues through deliberative discussions. The lesson was designed based on KB principles with Knowledge Forum (KF) as the main platform for students to engage in SAC on a chosen societal issue (Singaporeans' view of foreign manpower to the workforce). We analysed the impact of KB by examining students' ability to evaluate multiple perspectives of the issue and reach a well-balanced conclusion in terms of levels of response. A post evaluation survey was also conducted to measure the impact on students using a five-point scale. Results suggest that KB helped enhance the effectiveness of SAC with students being more engaged in the deliberation process and able to identify and consolidate multiple perspectives through collaborative KB discourse. Further considerations on the affordances of the KB approach for SAC would be discussed as well.

Introduction

Merits for deliberative discussions in the Social Studies classroom has been well-established in the revised Upper Secondary Social Studies Teaching and Learning syllabus guide. The guide states that deliberative discussions allow for "active and authentic learning experiences" through the exploration of multiple perspectives from varied sources of a societal issue. Students engaged in deliberation would gain the knowledge, skills and values that would mold them to become informed, concerned and participative citizens (MOE, 2016).

A common strategy of deliberative discussion is Structured Academic Controversy (SAC). First termed in 1979 by David Johnson and Roger Johnson, it was considered an instructional model for the process of controversy that allowed for students to deliberate on incompatible perspectives and reach for an agreement (Johnson & Johnson, 1988). Benefits of SAC included increased students' engagement, comprehension of societal issues and ability to identify the multiple perspectives of the issue (Avery, Levy and Simmons, 2014). It is with this premise that established SAC as an ideal deliberation model to be used in the Social Studies classroom.

Indeed, discussions of controversial issues enliven the subject. However, the challenge was on elevating discussions to a higher level where students were not just drawn towards them but develop a keenness to pursue explanations that can help them to understand the complexities of these controversies. Recognising the need for students to pursue explanations progressively without much constrains, Bereiter and Scardamalia (2012), proposed the Knowledge Building (KB) approach that can help bring discussions to that higher level, which allowed for quality learning of conceptual content. They postulated that KB could provide such higher-quality of learning as compared to traditional methods of content acquisitions, which is becoming increasingly inadequate when helping students comprehend the increasing complexities of theories in the Social Sciences. Therefore, through this study, it is beneficial for us to examine how we can use the KB approach to enhance the effectiveness of SAC in a Social Studies classroom.

Planning and Conducting Structured Academic Controversy in the classroom

Johnson & Johnson (1988) recommended four steps for organising the conduct of SAC in the classroom – 1. Choosing the discussion topic, 2. Preparing instructional materials, 3. Structuring the controversy and 4. Conducting the controversy. A detailed summary of the four steps is shown in figure 1:

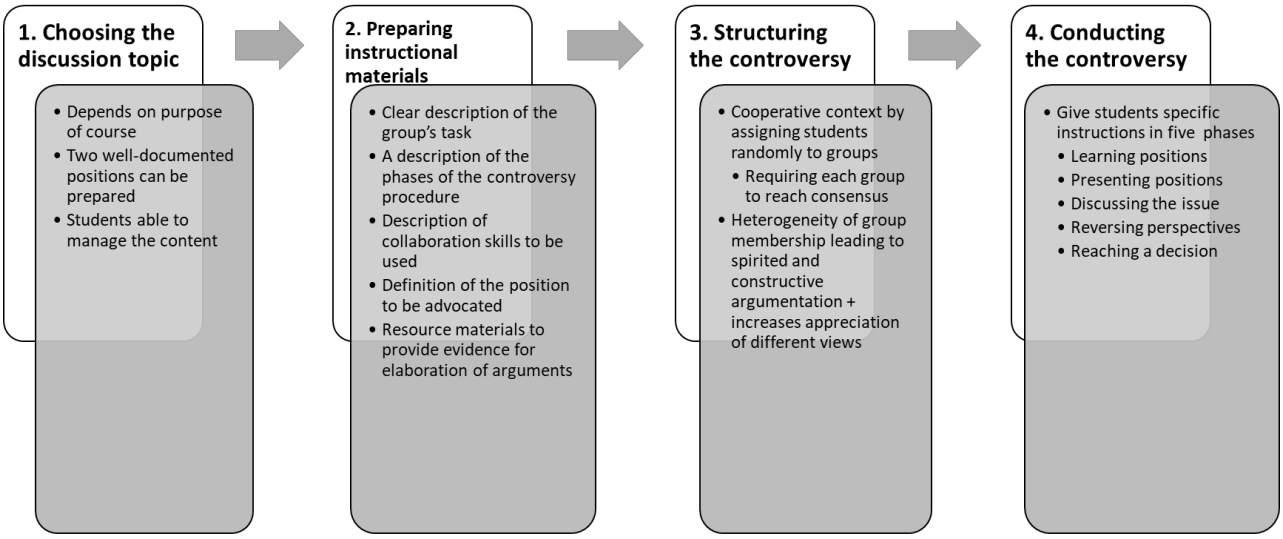

Figure 1: Four steps of organising SAC (Johnson & Johnson, 1988).

Principles guiding Procedures: Using Knowledge Building for Structured Academic Controversy

KB is a principle-based approach that guides practitioners in making informed decisions on designing their lessons. One key KB principle is Improvable Ideas, which treats every idea as improvable. For young students, the initial stage of generating theories and ideas do come naturally and easily, but improving them does not (Bereiter and Scardamalia, 2014). The KB approach thus help provide a structure for students to be engaged in idea improvement. The same can be said for deliberative discussions of controversy. For deliberation to be successful, "students must follow the canons of rational argument", that is, procedural approach of generating, collecting and organising relevant ideas and information, construct logical reasoning, recognising opposing perspectives and make well-informed conclusions based on the discussion. Only through planned structured procedures/steps would students be able to engage in deliberative discussions of controversy and help them practice adopting a perspective and enlarging their view to include the opposing position as well (Johnson & Johnson, 1988).

While Johnson and Johnson (1988) recommended four steps to plan and conduct SAC in the classroom, we argue that the KB approach can help enhance the steps and overall effectiveness of SAC. Theoretically, Bereiter and Scardamalia (2014) believed that prescribed procedures could "undermine the purposes for which they were originally designed" and perhaps cause deviations from their original intend. On the other hand, principled-based approach would provide an "important regulative function" for teachers that would help to "stimulate and guide rather than impede pedagogical invention" while guiding the essential procedures to be generative and evolving in favourable ways. In essence, a principle-based KB approach would provide regulative function that can ensure the effective conduct of SAC and guide its procedures.

With the above in mind, we begun to select the key KB principles that can help guide the design of SAC. Six key KB principles[1] were selected: "Real Ideas, Authentic Problems", "Idea Diversity", "Improvable Ideas", "Constructive use of sources", "Rise above" and "Knowledge-Building discourse". With these principles, we proposed a framework that can help guide in the planning and conduct of SAC in a Singapore Social Studies classroom and our lesson design for this study as shown in table 1:

Table 1: Framework of Knowledge Building for Structured Academic Controversy in Social Studies.

KB Principles	Aligning with Johnson & Johnson (1988) four steps of organising SAC.	How it can help guide the planning and conduct of SAC in Social Studies	How it guided the design and conduct of the lesson study
"Real Ideas, Authentic Problems"	1. Choosing the discussion topic	• Selection of societal issues that are **real and relevant** to students as **citizens** of Singapore. • Based on the Social Studies curriculum (Living in a diverse society)	• Topic on Living in a Diverse Society (Singapore's context) • Singaporeans' view of foreign manpower in the workforce
"Idea Diversity"	1. Choosing the discussion topic 2. Preparing instructional materials 3. Structuring the controversy 4. Conducting the controversy	• Selecting societal issues with clear diversity of views that students can manage that is within the curriculum. (Choosing) • Inform teachers on how to design the pedagogical approach on planning e.g. in guiding the preparation of sources that would promote a different interpretations towards the issue. (Preparing) • In structuring for SAC, students are divided into groups and tasked to take up one of two positions pertaining to the issue. (Structuring) • Provide materials/platform that can allow students to **learn** and **present** their positions with specific instructions guiding these phases. (Preparing + Conducting)	• Clear diverse view (disagreement vs agreement of foreign manpower being valuable to the workforce in Singapore • Availability of KF platform for students to learn and present their respective positions.
"Ideas Improvable"	2. Preparing instructional materials 3. Structuring the controversy 4. Conducting the controversy	• In SAC, all positions taken are treated as **"improvable"**. Not just towards the quality of presenting one of two positions but **taking a step in understanding the other position**. (Preparing + Structuring) • **Discussion** of the issue start to take place with groups of differing position start to **"build-on"** to each other's position by presenting their alternate position and provide critique of the other group's quality of presentation. (Structuring + Conducting) • Provide materials/platform that can allow students to **"build-on"** to each other positions with specific instructions guiding this phase. (Preparing + Conducting) • **In essence, a culture of building-on to each other's ideas through an exchange of position.**	• Views to the issue are treated as improvable since it requires students to present and discuss the two positions through KF. • KF allows the build-on of sharing between groups.
"Rise-Above"	3. Structuring the controversy 4. Conducting the controversy	• In SAC, students do not just comprehend the two positions but **synthesise** the positions and **reach** a **well-balanced, informed conclusion** to the societal issue. • **In essence, "putting their knowledge together" for this SAC.**	• Upon reading and discussing the two positions, each group would synthesise the relevant position by "Putting their knowledge together" and develop a well-balanced, well-reasoned conclusion on Singaporeans' view of foreign manpower by the end of the lesson.
"Constructive use of sources"	2. Preparing instructional materials	• Teacher selects **relevant source**s based on the issue that can help **provide evidence for elaboration** and reasoning for students to **construct their respective positions** towards the societal issue. • Teachers can also provide relevant sources that are more recent.	• For this discussion topic, a case study of it and the sources can be found in the Social Studies coursebook, which students have ready access to.

"Knowledge-Building discourse"	Achieving the desired outcomes of SAC	• Leading to the desired outcomes:
		  • Understanding the complexities of societal issue through **knowledge building discourse** of multiple perspectives, welcome the alternative position and make improvements on their write-up + understand through the synthesis of positions + ideas.
		  • Ultimately, have a deeper understanding of the issue and becoming more **well-informed.**
			• Students able to identify the two positions and develop a well-balanced conclusion would lead them to have a bigger comprehension of other controversial topics i.e. need to comprehend societal issues by understanding the multiple perspectives of multiple social actors
			• In assessment, practice of making valid source inference and understand the nature of source-based case study
			• In content and knowledge, understanding a specific experience of living in a diverse society like Singapore involving locals and foreign manpower.

A model of the framework to visualise the role of KB principles guiding SAC procedures can be seen in figure 2 below:

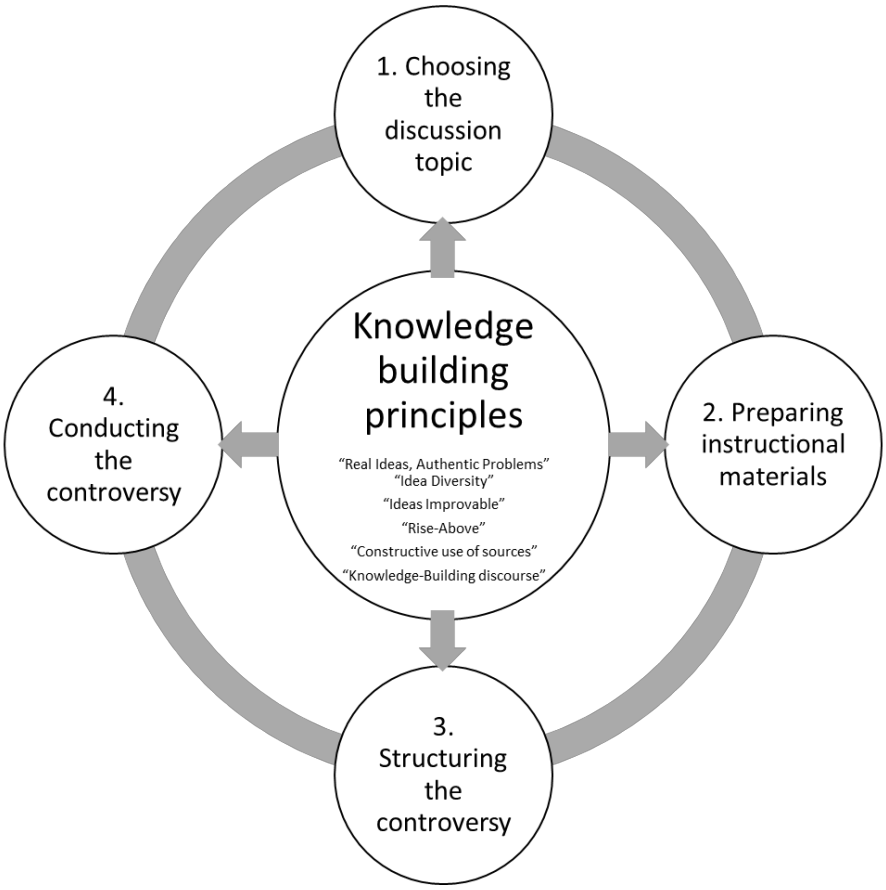

Figure 2: Model of Knowledge Building for SAC.

Affordance of technology: Using Knowledge Forum to conduct SAC

A common platform used for KB discourse is the Knowledge Forum (KF). A key feature of KF is the availability of theory-building scaffolds that can help guide students in productive thinking and discussions (Bereiter and Scardamalia, 2014). The platform supports the conduct of SAC as it allow students to create notes (or new theories), build-on, revise and synthesise information with the use of the scaffolds. Overall, KF is a suitable platform that allows students to collaboratively engage in SAC while seeing how students' ideas and understanding develop through the discourse.

Design and conduct of a principle-based SAC lesson

Using the framework in table 1 and having selected KF as the platform for the preparation and conduct of SAC, we proceed with a SAC lesson design for a Social Studies class and conduct a lesson study. The selected student participants (N= 32) were from one secondary 3 (grade 9) class in a government-aided school. The class is an express class and are considered middle-achievers. The duration of the lesson is one and a half hours.

In selecting the discussion topic based on the principle of "Real Ideas, Authentic Problems", the teacher selected the issue on Singaporeans' view of foreign manpower to the workforce. The topic selected is real and relevant given that students are living in a diverse society where Singapore's workforce is becoming increasingly diverse due to Globalisation and Singapore's position of being an open economy reliant on trade and movement of manpower. It is a discussion topic aligned to the Detailed Syllabus Outcomes for students to understand that there are both positive and negative experiences to living in a diverse society (MOE, 2016). The issue is deemed as controversial because there is clear diversity of views of whether foreign manpower can be viewed as valuable to the workforce by Singaporeans, which is in line with the principles of "Idea diversity" and "Ideas Improvable".

Ultimately, it is important that students do not just adopt one perspective but deliberate on the issue and formed a well-balanced conclusion through collaborative discussion and synthesising of relevant information.

The lesson is designed in three iterations with detailed instructions of each iteration spelled out to students on KF. Phase one required students, group in pairs, to learn and present their respective positions. Eight groups would take the position that Singaporeans do not view foreign manpower valuable to the workforce (they're classified as group A) while the other eight groups take the alternate position (they're classified as group B). The detailed instructions of phase one found on KF can be seen in figure 3a (see point 3):

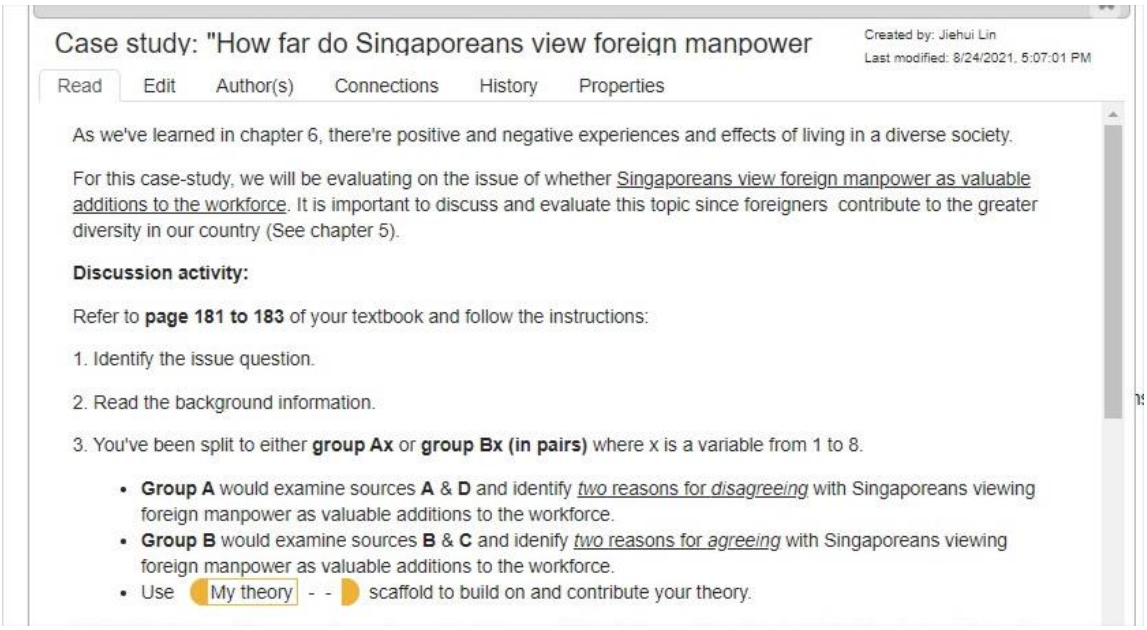

Figure 3a: Detailed instructions of phase one of SAC lesson design on KF.

In iteration two, groups taking one position are required to read the other groups' alternate position and build-on through the use of theory-building scaffolds of "I have new information" and/or "I need to understand". Through the use of "I have new information" scaffold, groups are require to present their other positions with supporting evidence and reasons to the other group i.e. group A share their position to group B and vice-versa using the build-on function found in KF. Groups are also given the autonomy to critique and clarify any unclear explanations provided by the other group. The detailed instructions of phase two found on KF can be seen in figure 3b:

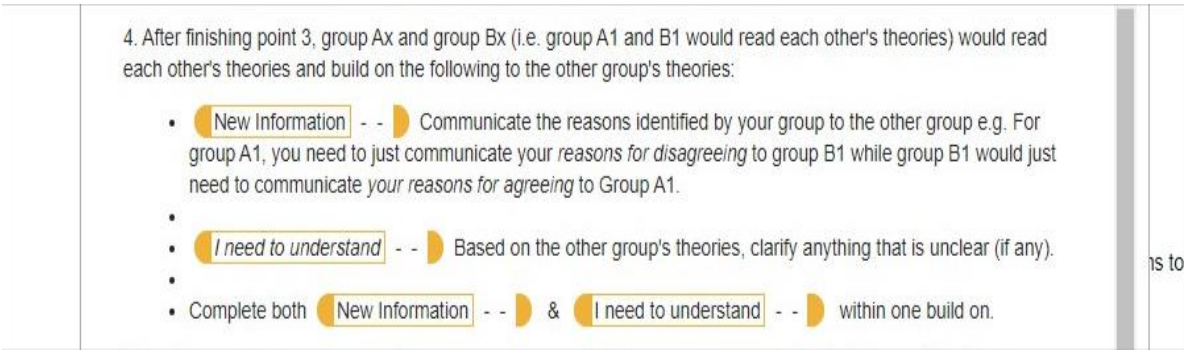

Figure 3b: Detailed instructions of phase two of SAC lesson design on KF.

Lastly, in iteration three, individual groups are required to, based on the information given by the other group, synthesise and developed a well-balanced conclusion to the issue. The detailed instructions of phase three found on KF can be seen in figure 3c:

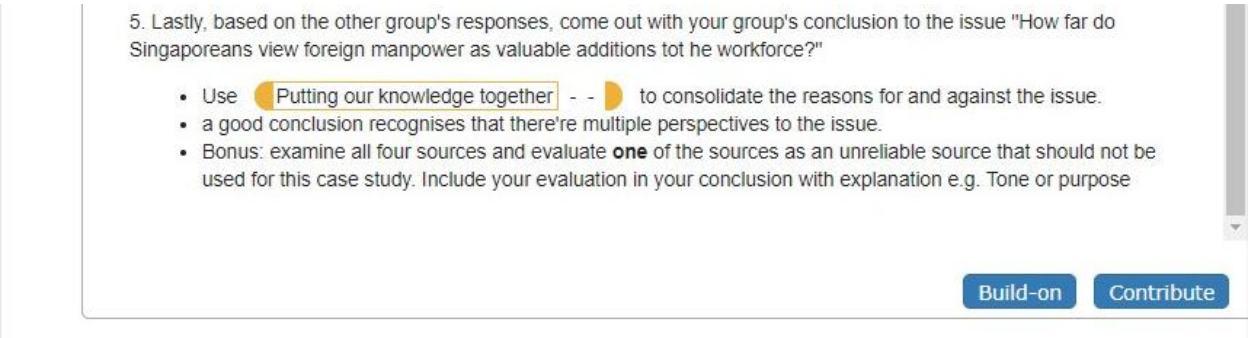

Figure 3c: Detailed instructions of phase three of SAC lesson design on KF.

Analysis of lesson study

To examine how the KB environment impacted students' engagement in SAC, we focused on students' notes at iteration three and examine their synthesis and development of their well-balanced conclusion to the issue. We use four levels of response to categorise the quality and depth of synthesis as seen in table 2:

Table 2: Levels of response at iteration three of SAC.

Levels of response	Descriptions	Examples
Level 1	Recognised the two positions but made no attempts of synthesis.	Just recognising/listing the two positions of the issue without any attempts of synthesis.
Level 2	Compared similarities and differences of the two positions.	Attempted synthesis by making comparison of the two position with the use of a basis of comparison.
Level 3	Critical analysis of the other group's responses by providing further analysis beyond what was presented in iteration two.	Used the other group's responses and made further interpretation beyond what was presented; Reversing perspectives and explaining complexity of the issue.
Level 4	Moved beyond the discussion topic by linking what they have learned of the issue to the broader curriculum content and understanding of controversy.	Examine whether students made links to the broader core concepts of the curriculum topic – Experiences of living in a diverse society. Further examine if students applied skills for analysis of the reliability of sources.

We would also be examining students' perspectives of the lesson by conducting a post-lesson evaluation survey using a five –point scale ranging from 1 = "strongly disagree" to 5 = "strongly agree" towards a series of statements in relation to the lesson study. The series of statements used in the post-lesson evaluation survey can be found in table 3:

Table 3: Statements used for post-lesson evaluation survey.

Statements	Purpose
"For today's lesson, I was confident of identifying the various arguments for and against the issue statement"	Examine students' perceptions in their ability to identify the two positions through the given sources.
"For today's lesson, I was confident of constructing a well-reasoned balanced conclusion"	Examine students' perceptions in their ability to develop well-balanced conclusion.
"From today's lesson, I came to learn that ideas and theories are best improved through discussions in groups."	Examine students' perceptions on the role of discussions in developing their learning and gaining of new knowledge/ideas/theories.
"Knowledge is best acquired through collaboration and sharing"	Examine students' perceptions on the importance of collaboration through KB in helping to gain knowledge.
"I am more comfortable participating in discussions through an online forum than having a face to face discussion"	Examine students' perceptions on how KF helped improved their learning experience through discussions.
"Being able to participate in discussions on Knowledge Forum has helped build up my IT skills and proficiency"	Examine students' perceptions on how KF helped to developed digital literacy and essential IT proficiency.
"I find myself being more engaged during today's lesson as compared to other lessons."	Examine students' engagement towards the lesson.
"Overall, I enjoyed today's lesson"	Examine students' overall perception towards the lesson.

Findings of lesson study (Examining of groups' synthesis based on table 2)

It was evident from the results that there were active involvement in theory development and attempts at synthesising varied build-ons and contribution to develop a well-balanced conclusion. Out of the 16 group entries, one group did not attempt any conclusion, four were at level 1, four were at level 2, four were at level 3 and three managed to reach level 4. An example of one group's KB discourse at the three iterations can be seen below:

Group A3 provided an initial position of disagreeing with the issue by presenting their position with support evidence and elaboration from the two given sources (A & D), using "*My theory*" KB scaffold:

> *My theory: "Source A: the student's reason for disagreeing with Singaporeans viewing foreign manpower as a valuable addition to the workforce is because of the competition that he faces. In the source the student states that "I'll be facing great competition from them" this states that the students will face a challenge with employment because the probability that a foreign talent with greater experience will be hired instead of him. This would lead to a disparity and inequality for employment for Singaporeans. As such this is why the student's reason for disagreeing with Singaporeans viewing foreign manpower as a valuable addition to the workforce because of the competition he faces.*
> *Source D: the workers' reasons for disagreeing with Singaporeans viewing foreign manpower as a valuable addition to the workforce is because of a biased prejudice amongst employers for Caucasian executives. In the source the worker says "there is a prejudice amongst employers that Caucasian executives are 'outgoing', more ' creative ', more ' intelligent ' etc , than our own locals. This is not true as our locals have the capability to match these foreigners and do what they can do. From the source we can derive that there is a prejudice of the fact that foreign talents are usually more skilled, more adept, and generally better overall in doing work as compared to Singaporeans amongst the employers. For this reason, the workers' reasons for disagreeing with Singaporeans viewing foreign manpower as a valuable addition to workforce is because of a biased prejudice amongst employers for Caucasian executives."*

In iteration two, Group B3 build-on to group A3's initial position and provided their group's other position, which differs from group A3, with the use of KB scaffold *"new information"*:

> *New information: "1) the foreign worker's manpower are as valuable as they are able to strengthen the relationship to increase efficiency in the workforce. 2) Singapore has its own capabilities and also strengths. However, having foreign workers being in Singapore being an additional value in Singapore, helps with the economic positively."*

Lastly, in iteration three, group A3 internalised and used group B3's build-on to synthesise both positions and develop their well-balanced conclusion, with the use of KB scaffold *"putting our knowledge together"*:

> *Putting our knowledge together: "In short, the arrival of foreign talents to Singapore brings upon a lot of advantages and disadvantages. Some advantages include the sharing of knowledge from more experienced, professional, and adept talents to the less skillful talents, and how foreign talents will add onto Singapore's economic value. However, this comes at a disadvantage, which includes more competition for Singaporeans and a workforce inequality, which could potentially lead to disparity amongst employment rates for Singaporeans and foreigners. In conclusion, regardless of the consequences that foreigners bring upon Singapore, there are multiple perspectives that can be seen to it. We should take upon this positively and welcome the benefits that can occur, whilst at the same time attempt to rectify the negatives that the influx of foreigners bring"*

Through the example, we could see an enactment of SAC taking place between the two groups. It was clear that there was engagement of KB discourse of the issue, leading to better comprehension of the issue as seen from group A3's recognition and synthesis of the two positions based on the *"new information"* provided by group B3. Through the SAC, Group A3 went beyond the societal issue and evaluated the topic based on the broader concepts, highlighting clearly the advantages and disadvantages brought about by foreign manpower. Even better, group A3 came out with a form of appropriate resolution, based on the positions, by acknowledging the benefits brought by foreign manpower to Singapore, while also acknowledging the importance on "rectifying" the negatives of the disadvantages. Overall, a well-developed balanced conclusion beyond the discussion topic.

The findings based on the notes at iteration three suggest that the KB approach helped to enact effective SAC where the use of build-on, collaborative dialogue between groups and scaffolding led to improvements and/or synthesis of ideas towards the understanding of the discussion issue and its core concepts. Nonetheless, it is noteworthy that, only seven out of the 16 groups managed a level 3 response. Further iterations, dialogues and scaffolding would be needed to guide the groups in making improvements on their conclusions and should not be limited to just one round of iteration for students to develop their conclusions.

Findings of lesson study (Based on post-lesson evaluation survey)

Out of the 32 students, 28 students provided their responses to the post-lesson evaluation survey. Table 4 below provided a summary of the survey results:

Table 4: Results from post-lesson evaluation survey.

Statements	1 – Strongly Disagree	2	3	4	5 – Strongly Agree
"For today's lesson, I was confident of identifying the various arguments for and against the issue statement"	0%	0%	35.7%	32.1%	32.1%
"For today's lesson, I was confident of constructing a well-reasoned balanced conclusion"	0%	3.6%	42.9%	28.6%	25%
"From today's lesson, I came to learn that ideas and theories are best improved through discussions in groups."	0%	3.6%	28.6%	35.7%	32.1%
"Knowledge is best acquired through collaboration and sharing"	0%	0%	32.1%	28.6%	39.3%
"I am more comfortable participating in discussions through an online forum than having a face to face discussion"	0%	7.1%	32.1%	32.1%	28.6%
"Being able to participate in discussions on Knowledge Forum has helped build up my IT skills and proficiency"	3.6%	0%	28.6%	32.1%	35.7%
"I find myself being more engaged during today's lesson as compared to other lessons."	0%	3.6%	35.7%	28.6%	32.1%
"Overall, I enjoyed today's lesson"	0%	0%	28.6%	32.1%	39.3%

Across all statements, at least 60% of the 28 respondents indicated a four or five towards the statements, while only a few indicated a one or two to some of the statements. The results suggest that majority of the students viewed the lesson positively and the KB approach could possibly help students be better engaged and be facilitated through the phases of SAC.

Discussion and Conclusion

The results suggest that the KB approach can help enhance the effectiveness of SAC with students being more engaged in the deliberation process and able to identify and consolidate multiple perspectives through collaborative KB discourse. With this, we go in-depth to discuss on how the KB approach can help further enhance the effectiveness of SAC.

One important element of SAC is "Epistemic curiosity" (Johnson & Johnson, 1988). "Epistemic curiosity" entails the "active search for more information and understanding opposing positions and rationale." KB facilitates this process very well as it opens up epistemic agency that encourages a climate of "build-ons" where students keep on improving their ideas that would lead to developing clearer understanding of the positions in relation to a societal issue. KF with the KB scaffolds allows for constructive development of ideas through collaboration and, as seen with this lesson study, effectively facilitate the process of exchanging and understanding opposing positions. As Bereiter and Scardamalia (2014) professed, KF is where the "state of knowledge materialises, takes shape, and advances", allowing students develop essential knowledge and skills of discourse.

Another important element required students to be engaged in "Reconceptualisation" that includes notions of "accuracy of perspective-taking, incorporation of opponents' information and reasoning, attitude and position change", further leading to "transition to higher stages of cognitive reasoning." (Johnson & Johnson, 1988). Again, KB help facilitates this process as it requires students to become "self-distanciation", simply means, being detached

from one's own position, allowing the student to examine his /her own position in relation to other ideas and therefore, draw new distinctions (Bereiter & Scardamalia, 2012). In other words, KB encourages student to always consolidate and synthesise ideas, after which, continue deliberating on improving them when new information appears. In short, KB perfectly complement SAC to achieve the desired outcome in the "promotion of creative insights by influencing students to view a problem from different perspectives and reformulate it in ways that allow the emergence of new orientations to the problem" (Johnson & Johnson, 1988). Overall, it was exciting for us to try out SAC using the KB approach and proposing it as an ideal approach to enact effective SAC.

[1] Comprehensive list of Knowledge Building Principles: https://www.kbsingapore.org/12-principles-of-kb. The selection of the six principles were guided by the recommendation of KB Singapore starter's resource kit.

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From Belief Mode to Design Mode: An Exploration of Discourse Moves in a Professional Learning Community, a Professional Learning Network, and a Global Innovation Network

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Abstract: Just like student learning, teacher learning is highly collaborative and discursive – and as in many learning contexts, it is simply easier to engage in idea sharing than idea improvement. The Knowledge Building challenge, therefore, is to find ways to engage teachers in design mode discourse – discourse aimed at reframing, extending, and improving practices – during professional development toward collective knowledge advancement. What types of social and technological supports might facilitate design mode discourse? In this paper, we examined the type of discourse moves that occurred in three different contexts: a professional learning community, a professional learning network, and a global innovation network. Using an emergent coding scheme, we found that as the professional development contexts increased in size, diversity, and complexity, teachers, administrators, and researchers were engaged in a broader range of discourse moves to sustain idea growth and idea improvement. Based on these preliminary findings, we provide a set of initial recommendations to deepen design dialogue during professional development sessions.

Introduction

Continuous teacher learning is key to school effectiveness and school improvement (Schleier, 2018); therefore, teachers need consistent structures and supports to critically examine and reflect on their practices. This includes having a space to openly share their problems of practice, ask questions, and discuss new ideas. A growing body of work suggests that effective teacher professional development initiatives share the following characteristics: 1) they place emphasis on deepening teachers' knowledge, 2) they support teachers' autonomy in trying out new practices in the classroom, and 3) they provide teachers opportunities to receive feedback on their practices in peer networks (e.g., OECD 2016; Fishman, Davis, & Chan, 2014; Darling-Hammond & Richardson, 2009). In this paper, we will examine how teacher learning unfolds in three contexts: a professional learning community, a professional learning network, and a global innovation network.

Professional Learning Community (PLC)

A professional learning community can be defined as a group of teachers working critically and collaboratively on questioning their current skillsets and practices in a goal-oriented manner (Stoll et. al, 2006; Toole & Louis, 2002; Mitchell & Sackney, 2000). In a PLC, teachers are committed to improving student achievement and are invested in discussing strategies with their peers to improve their practices (Higgins, 2016; Kincheloe, 2012; Little & McLaughlin, 1993). In some cases, teachers even become action researchers in their own classroom (Chuaraya & Brodie, 2017). Not only do PLCs contribute directly to instructional improvement, they also have the potential to lead school reform (Little, 2002).

Research suggests that in effective PLCs, teachers are willing to work together and take risks toward reinventing traditional pedagogies to support students (Borko, 2004). Put differently, collaboration and design thinking are key features of effective PLCs. In some contexts, however, the notion of "collaboration" can work against effective teacher learning. For example, in schools where teachers are encouraged to make instructional decisions individually rather than as a group, suggestions for improvements coming from their peers can be interpreted as critiques of practice (Rahman, 2011; Roberts & Pruitt, 2003). In schools where teachers interpret "collaboration" as a form of camaraderie, being nice and upbeat at the expense of being honest can hinder the design process as it can prevent teachers from receiving the feedback they might need to improve their practices (Levine, 2019; Evans, 2012; Dufour 2004). To address these issues, some scholars have recommended conceptualizing collaboration along a continuum to understand its effects on teacher learning (Glazier et al., 2017).

Ultimately, PLCs serve as one type of space for teachers to consistently come together and improve student learning and well-being, but if these meetings become a common space for sharing success stories rather than designing and improving classroom practices, these meetings will run the risk of having minimal impact on teacher learning, student outcomes, and school change. Therefore, school leaders and administrators need to intentionally

foster a culture of risk-taking with ideas by focusing on authentic, challenging problems and empowering teachers to test and confront their current practices (Chai & Tan, 2009).

Professional Learning Network (PLN)

When multiple professional learning communities come together, a professional learning network is formed. A professional learning network "compris[es] individuals from one or more schools and/or other interested organizations, who have come together from outside of their everyday community of practice to focus on achieving specific goals" (Brown & Poortman, 2018, p. 3). A PLN therefore goes beyond one school community to include a broader educational community comprising researchers, instructional coaches, and curriculum consultants to support teacher learning. PLNs aim to offer a wide range of opportunities for teachers to learn and grow as professionals by leveraging digital technologies to connect them with resources and experts that they may not otherwise have access to in their local contexts (Trust, Krutka, & Carpenter, 2016; Barab, Kling, & Gray, 2004; Yoon & Baker-Doyle, 2018). This virtual aspect of PLNs allows teachers to connect with one another based on emergent goals and interests. Essentially, when a problem of practice is presented, anyone who is part of the PLN can offer help to develop a solution (Duncan-Howell, 2010).

It can be said that PLNs take teacher learning to the next level by facilitating knowledge sharing and collaborative problem solving at scale. Because they are designed to facilitate the flow of knowledge and other forms of social capital, PLNs provide teachers access to multiple and diverse perspectives (Murphy & Laferrière, 2003; Poortman & Brown, 2021). For example, in a PLN, teachers from anywhere in the world can exchange ideas, strategies, and resources with other educators and experts (Flanigan, 2012). In this way, knowledge is democratized among participants and learning becomes more pervasive (Laferrière, Lamon, & Chan, 2006). Due to the flexible, self-directed nature of participation in a PLN, teachers have a lot of autonomy in crafting their path toward lifelong learning and continuous professional development (Trust, 2012). At the same time, without more structured forms of support, some educators may miss opportunities for growth available in PLNs (Krutka, Carpenter, & Trust, 2016).

Global Innovation Network

An innovation network is a group of "self-motivated people with a collective vision, enabled by the Web to collaborate in achieving a common goal by sharing ideas, information, and work" (Gloor, 2006, p. 4). A few distinguishing features of innovation networks include the decentralization of traditional hierarchies, optimization of knowledge flows through transparency, honesty, and sound ethical principles, and the use of a complex array of digital tools to self-organize around idea improvement (Gloor, 2016). A global innovation network, therefore, extends the work of PLNs beyond school improvement toward advancing the frontiers of education, transforming traditional structures in school systems that prevent innovation. Although innovation networks are not typically found in education, they have been used to frame the knowledge work of students in classrooms (Ma, Matsuzawa, & Scardamalia, 2016) and teachers engaged in sustained collaborative design during professional development initiatives (Ma & Scardamalia, in press).

Most notably, the Knowledge Society Network (KSN) was developed to scale up the work of professional learning networks across nations toward developing a global innovation network in education. The purpose of this global innovation network is to meet the "knowledge era challenges by immersing participants in the practice[s] of knowledge creation and innovation" (Hong, Scardamalia, & Zhang, 2010, p. 2), including open collaboration, peer production, and knowledge advancement. Going beyond democratizing and mobilizing knowledge, locally distributed teams create new knowledge and coordinate efforts to make symmetric advancements at a global scale through "inward and outward flow of ideas and network boundary crossing" to redistribute ideas and resources for equitable, inclusive, and sustainable participation across sites (Scardamalia et al., 2017, p. 704). During virtual sessions, members – including teachers, researchers, engineers, students, and policymakers – engage in design thinking, problem solving, and intentional learning through Knowledge Building discourse and constructive use of authoritative sources to develop rise above solutions that simultaneously advance theory, pedagogy, and technology. Discussions are sustained through iterative and collaborative design among participants supported by digitally networked technologies with embedded analytic tools, like Knowledge Forum (Scardamalia & Bereiter, 2021).

Whereas global innovation networks are designed with what Hong and colleagues (2015) refer to as an "innovation-oriented stance" – a commitment to challenging the status quo in order to develop new ideas, practices, and values – schools tend to place emphasis on streamlining "best practices". For example, while a group of teachers might work together in collaborative design (Kali, McKenney, & Sagy, 2015), their design work is typically focused on lesson plans, activity structures, and technology supports, with little attention paid to ideas that might actually transform the goals of schooling. As Scardamalia and Bereiter (2016, p. 9) point out, in schools, "ideas are dealt with in traditional justification mode fashion. They are things to argue about, criticize or advocate; they are not

things to improve or reconstruct". One way to shift this orientation toward ideas is through Knowledge Building discourse (Scardamalia & Bereiter, 2006), discourse aimed at reframing problems, seeking alternative perspectives, and deliberately advancing ideas through progressive problem solving. Knowledge Building discourse is characterized by two modes of work with ideas: design mode and belief mode. Whereas discourse in design mode focuses on the improvability and promisingness of ideas, discourse in belief mode focuses on the validity and reliability of ideas. Both modes of discourse are needed to generate new knowledge and advance collective understanding (Bereiter & Scardamalia, 2003). This means that teacher learning can be deepened even further when teachers are given sustained opportunities to shift between design mode discourse and belief mode discourse during collaborative design.

Past work indicates that teacher discourse in professional development contexts tends to operate largely in belief mode, characterized by what Lord (1994) refers to as "critical colleagueship", such as critical analysis of practices (Popp & Goldman, 2016) and knowledge sharing (Kintz et al., 2015). Discourse moves typically include joint questioning, explaining thinking, and negotiating fit between ideas, with virtually no creation of new ideas. More recent work, however, is suggesting that teachers can also adopt an innovation-oriented stance toward the culture of schooling by engaging in more design mode discourse during professional learning community meetings (Zhang et al., 2011) and professional learning network sessions (Teo, Ong, & Tan, 2021).

Study Design and Datasets

Based on the literature review, it can be seen that teacher learning is highly collaborative and discursive. Professional learning communities, professional learning networks, and global innovation networks each offer a unique set of affordances for facilitating teacher discourse and collective knowledge advancement. The purpose of this study, therefore, is to explore the different types of discourse moves that occur in these three professional development contexts in order to determine different strategies that participants used to shift between belief mode and design mode during their collaborative discourse.

1. What types of discourse moves naturally occur in professional learning communities, professional learning networks, and global innovation networks?
2. Are there similarities and/or differences in how participants engaged in design mode discourse based on their roles? If so, which discourse moves did different professionals tend to use in these contexts?

To address these questions, data was aggregated across three different research sites where participants engaged in advancing principles-based, evidence-based practices in schools. In all three contexts, participants were committed to implementing Knowledge Building in their classrooms and joined the virtual space with the intention of learning from and reflecting with their peers. Therefore, participants entered each professional development session voluntarily with at least some understanding of Knowledge Building theory, pedagogy, and technology. The common goal across each research context was to engage participants in collective knowledge advancement through synchronous discussions online. A brief description of each research context is provided below.

Professional Learning Community

The first research site is a professional learning community in an elementary school in Canada. Participants in this PLC include 2 administrators (principal and vice-principal) and 12 teachers (nursery to grade 6) who meet biweekly over the course of the school year to provide sustained opportunities for teachers to reflect on their practices. Participants discussed topics related to big ideas in the curriculum, characteristics of a good question for inquiry, designing age-appropriate learning activities, metacognitive tools and assessment strategies, and new evidence from books and studies. The dataset from this context that was used for analysis comprises video transcripts from two virtual meetings (approximately 100 minutes).

Professional Learning Network

The second research site is a professional learning network spanning multiple school districts in Singapore. Participants in this PLN include 10 teachers (elementary and secondary), 3 researchers, and 1 ministry personnel who meet quarterly over the course of the school year to provide sustained opportunities for teachers to exchange ideas, practices, and resources. Participants discussed topics related to philosophies of teaching, attributes of 21st century learners and classrooms, strategies for socio-emotional learning, and structuring discourse for critical thinking. The dataset from this context that was used for analysis comprises written discourse from one PLN virtual session spanning two days (approximately 40 Knowledge Forum notes). Participants used the theory-building scaffolds on Knowledge Forum to sustain idea improvement (e.g., My theory, I need to understand, New information, A better theory, Putting our knowledge together).

Global Innovation Network

The third research site is a global innovation network spanning 9 nations and 20 educational institutions. Participants in this innovation network include 20 researchers (learning sciences, teacher education, educational technologies, educational policies) and 10 teachers (elementary and secondary) who meet quarterly over the course of the year to discuss research advances in Knowledge Building theory, pedagogy, and technology. Participants discussed topics related to pressing design challenges in local contexts, such as how to give students' ideas more presence in the classroom, how to design for collective responsibility in the elementary/secondary/post-secondary classroom, how to design customizable learning analytic tools to give students more agency in the learning process, and promising ideas for future teacher-researcher collaborations. The dataset from this context that was used for analysis comprises video transcripts from two virtual sessions (approximately 150 minutes) and the accompanying written discourse during these sessions (approximately 80 Knowledge Forum notes). In addition to the classic set of theory-building scaffolds on Knowledge Forum, participants used a customized set of scaffolds to deepen design mode discourse (e.g., What we tried, What didn't work, How we improved, What we will try next, Our observations/reflections).

Methods of Analysis and Preliminary Findings

To address the exploratory aims of this study, we adopted a grounded theory approach (Strauss, 1987) to identify the discourse moves that naturally occurred in each research site. Therefore, each dataset was coded twice using an inductive process to first develop and then refine our coding scheme. During the first round of coding, seven main codes emerged (column 1 of Table 1): defining a problem, making connections, asking questions, self-reflection, playing with ideas, making opinions, and miscellaneous (e.g., administrative issues, timekeeping, tech support). During the second round of coding, some codes were further expanded into subcodes to convey more nuanced moves in the discourse (column 2 of Table 1). This means that each turn in discussion (i.e., speaker utterance or KF note) was given one specific code based on column 1 of Table 1 during the first round of coding and then updated with a subcode based on column 2 of Table 1 where applicable. For example, when participants were making connections, sometimes they would connect ideas within the existing discussion, sometimes they would relate back to their personal experiences, and still, other times, they would bring in new ideas from research studies. Likewise, when participants were asking questions, sometimes they would ask for clarification to deepen understanding, while at other times, they would introduce a thought-provoking idea that would spark new or unexpected directions for discussion.

Table 1: Coding scheme for discourse moves in professional development contexts.

Code	Subcode	Description
Defining the problem	N/A	Identifying issues or emerging issues with current designs and/or classroom practice.
Making connections	Connection based on an agreement	A connection is made between one or more ideas by agreeing with current design and/or practice.
	Connection based on personal experiences	A connection is made between an idea that is related to past or current experiences.
	Connection based on other studies	Identifying connections between different research studies.
Asking questions	Clarifying question	A question is made to simply try and get a better understanding.
	Thought-provoking question	A question is made for idea improvement.
Self-reflection	N/A	A metacognitive piece stating their own research and/or practice.
Playing with ideas	Identifying a promising idea	A potential promising idea is highlighted and identified that can be tested out and analyzed afterwards.
	Creating new ideas	Synthesizing knowledge thus creating new ideas that can be applied for idea improvement.
Sharing opinions	Simple opinion	A short inference is made.
	Elaborated opinion	An elaborated inference is made with strong reasoning.
Miscellaneous	N/A	Statements that are off-topic and do not contribute to design thinking.

Due to the unique nature of our research sites and datasets, we decided to develop an emergent coding scheme as means to seek validity of discourse moves across all three professional development contexts. We posit that if it is the case that teachers, administrators, ministry personnel, and researchers are indeed engaged in Knowledge Building discourse, we would find empirical alignment with coding schemes used to assess the Knowledge Building discourse of educators (e.g., Popp & Goldman, 2016), as well as theoretical alignment with coding schemes used to depict the dynamics of Knowledge Building discourse (Bereiter & Scardamalia, 2016). Table 1 shows our coding scheme as well as a brief description of each discourse move.

To address the first research question, each dataset was coded using the coding scheme elaborated in Table 1 to explore the presence (or absence) of discourse moves across the three professional development contexts. To address the second research question, code frequencies were transformed into percentages based on roles (i.e., teachers, administrators, researchers) to explore the relative distribution of discourse moves contributed by different participants in the different contexts. Despite sharing common goals, each context varied in terms of duration of sessions, length of discussions, number of participants, diversity of expertise, and technological supports. Therefore, percentages allow us to better visualize discourse patterns across the three professional development contexts to see whether additional commonalities would emerge. Figures 1, 2, and 3 provide an overview of discourse moves in the first research site (professional learning community), the second research site (professional learning network), and the third research site (global innovation network), respectively. The discourse moves are represented on the y-axis, and the relative contributions of participants are represented on the x-axis.

Professional Learning Community Meetings

Figure 1 shows the distribution of discourse moves that occurred in PLC meetings involving teachers and administrators. It can be seen that participants were primarily engaged in self-reflection, asking questions, making connections, playing with ideas, and problem solving. In this context, while teachers tended to define the problem, identify promising ideas, and make connections to previous studies, administrators tended to lend support to teachers by asking clarifying questions, making connections based on personal experiences, and engaging in self-reflection. It is interesting to note, however, that while teachers and administrators both asked clarifying questions, neither asked thought-provoking questions.

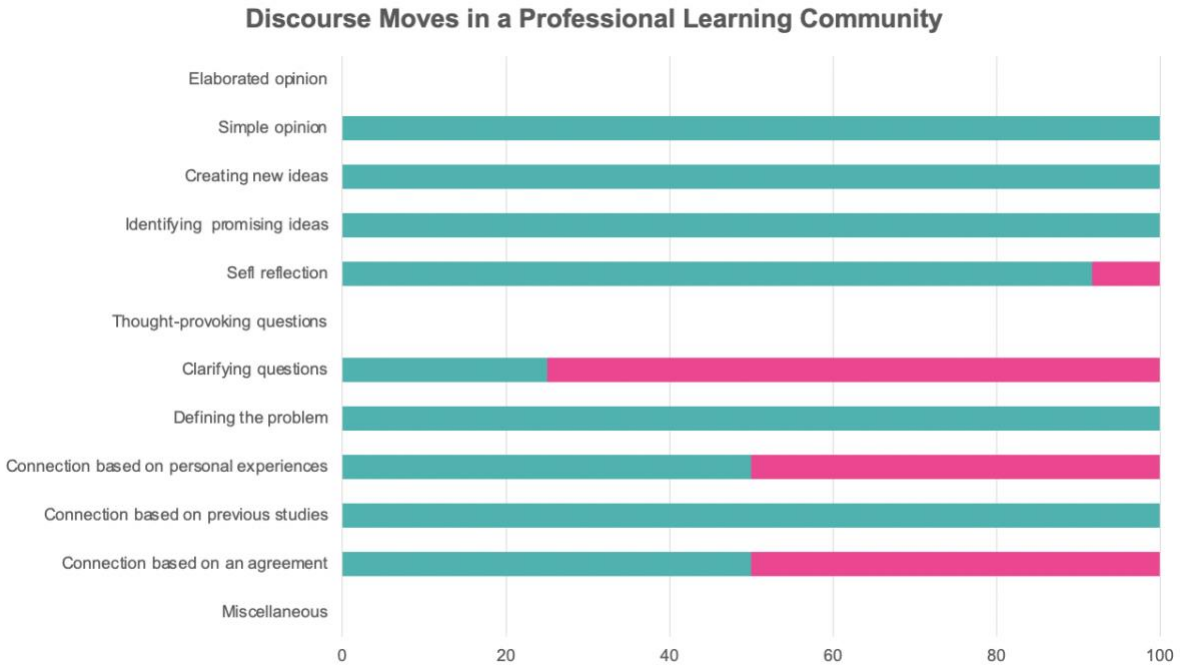

Figure 1. Overview of discourse moves in PLC meetings with teachers (green) and administrators (pink).

To illustrate the dynamics of the PLC meetings, we present two brief vignettes to highlight the flow between various discourse moves. In one meeting where teachers were discussing ways to deepen student learning in the classroom, the principal provided a definition of metacognition from an authoritative source followed by teachers taking turns

to share strategies they used with their students. One teacher shared how she designed a weekly survey for students to reflect on what they had learned and to identify things they still needed to understand. To build on this practice, the vice-principal asked whether student's weekly reflections would be shared with their peers during class discussions. The teacher explained that because the surveys were intended for instructional purposes (i.e., to assess students' learning progressions), she thought it would be better to keep the survey responses private. In another meeting where teachers were discussing students' scientific misconceptions, a teacher shared his concerns with regards to students' writing skills. While students showed high levels of engagement during group discussions, they were less enthusiastic when it came to writing and struggled to convey their scientific understanding in prose. The teachers grappled with this issue for a bit before a suggestion was offered to use multimodal features of technology, such as speech-to-text, to facilitate students' writing process. Whereas in the first vignette, participants made connections based on previous studies and personal experiences, asked clarifying questions, and shared simple opinions, in the second vignette, participants defined a problem of practice and identified promising ideas to move each other's work forward.

Professional Learning Network Sessions

Figure 2 shows the distribution of discourse moves that occurred in PLN sessions involving teachers, researchers, and a member from the ministry of education. It can be seen that participants were primarily engaged in self-reflection, asking questions, sharing opinions, making connections, playing with ideas, and problem solving. In this context, while teachers tended to identify promising ideas, share opinions, and make connections to personal experiences, administrators tended to ask clarifying questions and share opinions, while researchers tended to engage in problem solving, make connections to previous studies, and create new ideas. It is interesting to note that while teachers exclusively made connections based on personal experiences, researchers exclusively made connections based on research studies.

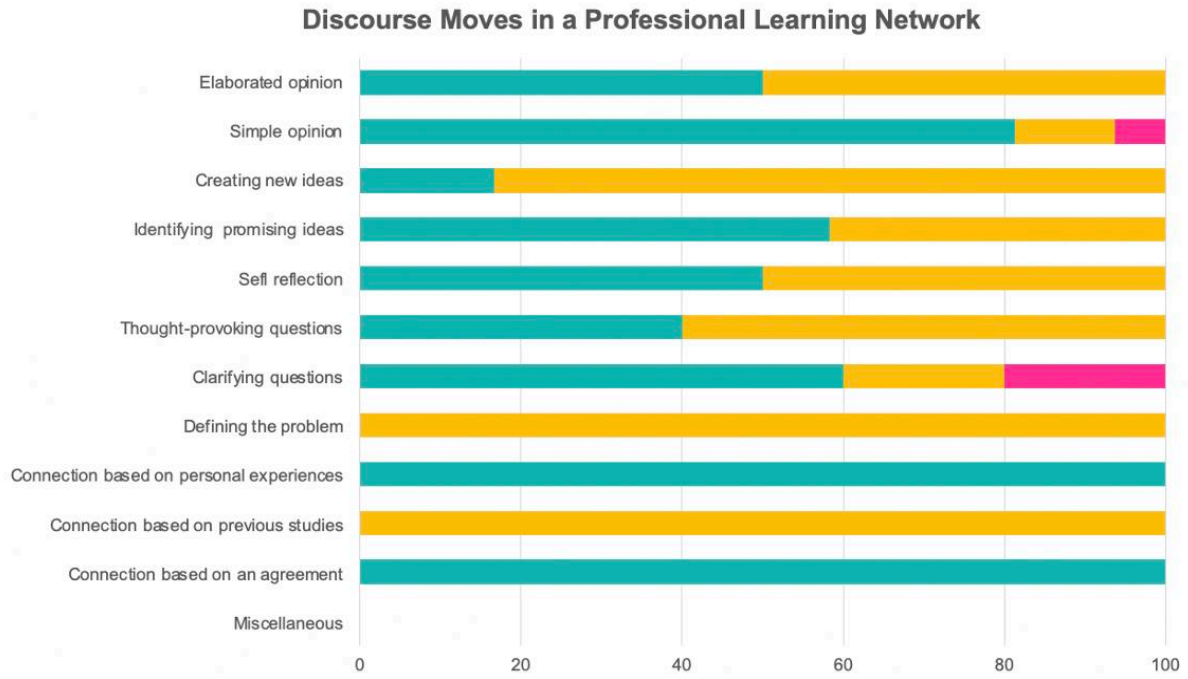

Figure 2. Overview of discourse moves in PLN sessions with teachers (green), researchers (yellow) and ministry personnel (pink).

To illustrate the dynamics of the PLN sessions, we present a brief vignette to highlight the flow between various discourse moves. The PLN session was structured so that the focus of the discussion on the first day was on the role of students in the Knowledge Building classroom, whereas the focus of the discussion on the second day was on the role of teachers in the Knowledge Building classroom. A teacher who was a newcomer to the network initiated the following discussion about fostering a KB culture in the classroom. The question she put forth was "[I need to understand]: How students learn and contribute to [each other's] ideas?". One teacher suggested nurturing a sense of

psychological safety "so that students dare to voice and ask questions" and "build[ing] the habit of questioning (in a polite way)". A researcher then reinforced this teacher's idea by highlighting the dual importance of using "questioning techniques as well as respecting the diverse voices of students" when fostering a culture of psychological safety. This discussion was extended into the second day where teachers reflected on their practices in light of the new question, "What are the attributes that teachers need in facilitating KB?". In this vignette, participants asked thought-provoking questions, identified promising ideas, shared simple opinions (e.g., showing support, agreement), and reflected together.

Global Innovation Network Sessions

Figure 3 shows the distribution of discourse moves that occurred in global innovation network sessions involving teachers and researchers. It can be seen that participants were engaged in all modes of discourse (e.g., self-reflection, asking questions, sharing opinions, making connections, playing with ideas, and problem solving) with a fairly even distribution of discourse moves between teachers and researchers in this context. While teachers tended to engage in self-reflection, sharing opinions, and making connections to personal experiences, researchers tended to engage in problem solving, asking both clarifying and thought-provoking questions, and creating new ideas. It is interesting to note that both groups were equally invested in self-reflection, identifying promising ideas, and making connections between ideas discussed throughout the virtual sessions.

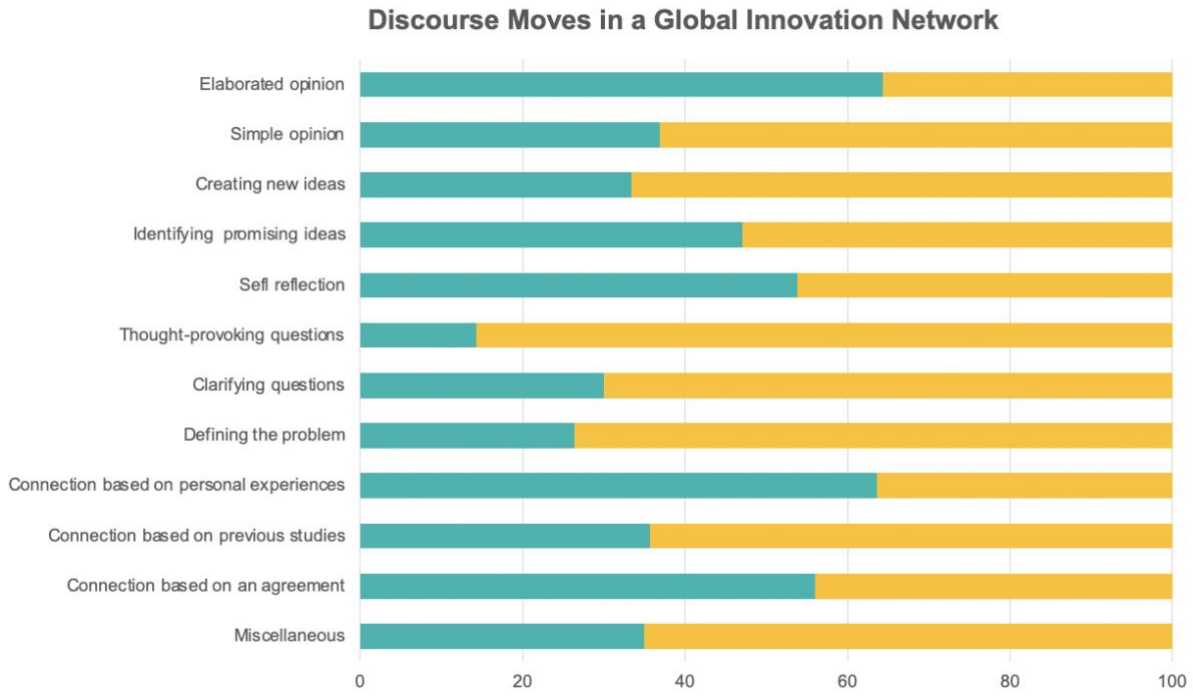

Figure 3. Overview of discourse moves in global innovation network sessions with teachers (green) and researchers (yellow).

To illustrate the dynamics of the global innovation network sessions, we present a brief vignette to highlight the flow between various discourse moves. During one session, a teacher-researcher team from Canada presented their design iterations over the course of an academic year to foster an idea-centered classroom. Although they had notes prepared, their presentation unfolded more like an improvised, reflective dialogue than a formal retelling of events. After the researcher summarized their design challenge and classroom context, the teacher shared a few reflections, including some strategies he tried with his students. The researcher then followed up with a question, inviting the teacher to share some of the challenges they had encountered during the implementation process, which opened up the opportunity for participants to develop possible solutions together. One issue that the teacher and researcher had identified was that students preferred playing with materials over playing with ideas. To address this issue, a teacher from Singapore suggested using a discussion strategy to shift the focus back to ideas. An alternative approach suggested by a researcher from Canada involved integrating think-aloud protocols while students played with

materials to make their ideas more explicit. This suggestion was further built on with the idea of using video to help students see their ideas embedded in their play. A researcher from the United States also added that it might be promising to juxtapose play with failure (i.e., rapid protoyping) during discussions. After this series of exchanges, researchers identified common themes across practices and teachers identified some promising strategies that they would try in their local contexts; both were engaged in finding new ideas to carry forward. In this vignette, participants asked questions, made connections based on previous experiences, identified promising ideas, created new ideas, and reflected together.

Discussion of Preliminary Findings

The purpose of this paper was to explore the different types of discourse moves across different types of participants in three professional development contexts: a professional learning community, a professional learning network, and a global innovation network. Our preliminary findings demonstrate that professional learning communities, professional learning networks, and global innovation networks all provide enabling conditions for teachers to engage in Knowledge Building discourse where they can identify shared problems of practice, exchange and connect ideas, ask questions to deepen understanding, and reflect on promising strategies to sustain continual improvement of practices. During PLC meetings, teachers were reflective around their own practices and open to sharing effective strategies with one another, however, there was a tendency to maintain collegiality through knowledge sharing rather than building on each other's practice through collaborative design. During PLN sessions, teachers demonstrated intellectual curiosity by asking thought-provoking questions and exchanging resources with one another. There was a tendency for newcomers to ask questions to experts and oldtimers to provide encouragement and support. During global innovation network sessions, teachers took risks with ideas by providing each other suggestions for improving practices and identifying promising strategies to try out in their classrooms. In a truly democratic and decentralized fashion, teachers and researchers were more or less equally engaged in idea improvement, with all members taking responsibility to rise above discussions by seeking integration across diverse perspectives and identifying emergent, shared issues to tackle in the next global innovation network session.

In all three contexts, teacher participation generally consisted of asking clarifying questions, identifying promising ideas, engaging in self-reflection, sharing opinions, and making connections to past experiences. Researchers, administrators, and ministry personnel, on the other hand, primarily served a supportive role in scaffolding the discourse toward collective knowledge advancement. Whereas researcher participation generally consisted of asking thought-provoking questions, engaging in problem definition, connecting ideas to relevant research, and creating new ideas, administrator participation generally consisted of asking clarifying questions and making connections between participants' ideas. Taken together, our findings suggest that design mode and belief mode cannot be captured in one single discourse move but rather, through a series of exchanges between participants. For example, asking questions can take place in both design mode and belief mode. When in design mode, a question of clarification about a teacher's practice can refer to promising aspects of their design. When in belief mode a question of clarification about a teacher's practice can lead to justification for certain design decisions. In a similar way, sharing personal experiences can be in both design mode and belief mode. When in design mode, connecting personal experiences with research studies can enhance real-world applications of evidence-based practices and open possibilities for cross-cultural validation. When in belief mode, connecting personal experiences with research studies can be used to reinforce the notion of best practices, rather than advancing them. Each of these discourse moves, then, serve as opportunities to shift from belief mode to design mode and vice versa.

In addition to considering the professional development context, the various roles of participants involved, and the content of the discourse, another important factor to consider is the role of technology in facilitating both modes of discourse. More specifically, in the professional learning network and global innovation network sessions, teachers and researchers received additional time and support to elaborate their theories and questions through written notes on Knowledge Forum. Specific design features of the technology, such as the theory-building scaffolds and the design mode scaffolds, likely played a role in bootstrapping the collaborative design process by encouraging participants to reflect more deeply on their own ideas and build on each other's ideas with more intention.

Implications for Future Work

Recall that both types of discourse – belief mode and design mode – are necessary for collective knowledge advancement (Scardamalia & Bereiter, 2016; 2017). Therefore, the current study is not advocating to replace all modes of discourse with design mode discourse in professional development contexts, but rather, our aim is to explore opportunities to shift between various modes of discourse as deemed appropriate by participants. These include (but are not limited to): defining the problem, making connections, asking questions, self-reflection, playing with ideas, and sharing opinions. Indeed, more work is needed to explore convergence across coding schemes,

including discourse moves that promote an "inquiry stance" (Popp & Goldman, 2016), as well as specific turns of discourse deemed as "good moves" during Knowledge Building (Bereiter & Scardamalia, 2016).

One area for future work includes designing more coherent forms of support for aligning collective knowledge advancement across multiple levels of professional development, including more explicit strategies to deepen the synergy between belief mode and design mode during collaborative design between teachers and researchers. Additional qualitative analyses are underway to identify promising turns of discourse that can help foster a culture of risk-taking with ideas and catalyze idea improvement during teacher learning. For example, our preliminary findings seem to suggest that presenting a problem of practice and/or asking thought-provoking questions might be one way to invite teachers and administrators into working creatively with ideas. Still, further analyses are needed to understand the role of thought-provoking questions in sustaining idea development (e.g., When is it appropriate to seek help from experts and/or introduce authoritative sources?) and the conditions that lead to the creation of new ideas during Knowledge Building discourse.

Another area for future work involves investigating the role of networked technologies, such as Knowledge Forum, in facilitating both modes of discourse over sustained periods of time across multiple research sites. For example, participants can reflect on their discourse moves using the analytic tools and examine shifts between belief mode and design mode as they relate to their evolution of thought over time. Moreover, participants can adapt our coding scheme into a set of KF scaffolds and/or integrate it with the existing set of KF scaffolds that was used in the global innovation network sessions. In the spirit of design, we invite teachers, administrators, ministry personnel, policymakers, and researchers to improve and expand this emergent typology of discourse moves as we see this conceptual artifact an integral part of our own Knowledge Building.

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Knowledge Building Analytics to Support Teacher Noticing and Scaffolding

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Abstract: Education reforms in science and other areas demand student-driven authentic inquiry through collaboration. Knowledge Building provides a viable model to address this need. However, it is challenging for teachers to implement and facilitate Knowledge Building driven by students' dynamic ideas in a classroom community, which requires new dynamic roles of teaching. This paper presents a framework of dynamic teaching for student-driven knowledge building, which focuses on teacher noticing and responsive scaffolding with analytics support. First, this paper discusses teachers' engagement in collaborative knowledge building through reflective noticing and envisioning for sustained inquiry. Next, it highlights the adoption of knowledge building analytics to support teachers' ongoing noticing. Grounded in the relevant literature, we suggest a framework about analytics support for reflective noticing and responsive scaffolding of knowledge building progress. Implications are discussed calling for promoting concurrent teacher noticing and envisioning with the integrated use of evidence-based feedback in the curricular settings.

Introduction

Innovation of education in the current era has emphasized exploring authentic problems and the development of knowledge in science (National Research Council, 2012). Students probe real-life issues and find resolutions to the problems in practice. They generate innovative inquiry, add ever-deepening ideas to ongoing discourse, take on communal responsibility, and advance and expand collective knowledge (Scardamalia & Bereiter, 2003). Still, discussions on such reformed education are going on with a further emphasis on student-driven collaborative learning (Bielaczyc & Collins, 1999). The reformed classroom contexts require flexible adaptations and revisions to support students' improvisational inquiry process over time (Sawyer, 2004).

Despite these needs, the field still lacks a deep understanding of designing and redirecting student-driven inquiry-based collaborative learning. In particular, more in-depth research should investigate teachers' role in students' collaborative knowledge building activities. Reflective teachers engage in students' knowledge building moves, see students' learning as a central object, think about the next direction, and envision responsive actions (Rodgers, 2002). By doing so, they push students' inquiry work forward, foster collaboration among students, and use necessary resources based on learning needs. They capture what they see and think about it, which leads them to design follow-up lessons. This process occurs in the subsequent classroom events and is iterated in a loop. To support this process of teachers' engagement with concurrent noticing and envisioning, additional backing is required. In this sense, it is inevitable to comprehend teachers' genuine role in enhancing students' collaborative idea progress and then explore what assistance helps teachers noticing and how it functions.

The present paper addresses teachers' reflective noticing and responsive scaffolding in student-driven knowledge building progress and adoption of analytics support. First, we describe teachers' reflective noticing in inquiry-based knowledge building. In particular, the teacher's role as co-learners is addressed in learning contexts based on Knowledge Building (KB) pedagogy, where teachers' pedagogical vision is intertwined with students' emergent inquiry progress. Next, we highlight the need to foster students' collaborative knowledge building with evidence-based feedback and guidance. We point out teachers' use of *KB discourse analytics* that investigates student-enhanced ongoing discourse when monitoring students' inquiry progress. Thus, we elaborate on a framework about analytics support for reflective noticing and responsive scaffolding in knowledge building communities. We then describe the limitations of current literature on teacher noticing and discuss the challenges and needs of adopting learning analytics in teacher noticing and scaffolding.

Reflective Noticing of Knowledge Building

Teacher reflection in students' learning is aligned with course progress and pedagogy (Greiffenhagen, 2012; Pellegrino & Gerber, 2012; Rodgers, 2002; Shulman, 1987). Notably, teachers' attentive reflection is critical in the learning context full of students' inquiry (Shulman, 1987), which needs to be deeply understood in authentic classroom settings and responded in line with students' understanding of subjects (Greiffenhagen, 2012; Jacobs et

al., 2010).

Teachers in the KB pedagogy contexts engage in reflective and adaptive pedagogical practices. They attend to students' ongoing inquiry and iteratively re-design customized pedagogy for enhancing students' collective idea progress (Sergis & Sampson, 2017; Zhang et al., 2011). Teachers' deep reflection builds insights for their professional development (Zeichner & Liston, 1996) and students' collaborative learning (Brookfield, 2017).

Studies conducted in the context of collaborative knowledge building showed the critical roles of teacher noticing (Judson, 2016). With reflective noticing and awareness of students' inquiry advancement and attitude, teachers can better play their roles to support and shape students' improvisational inquiry (Viilo et al., 2018) and facilitate knowledge connections between students' previous, current, and new inquiries. As immersed in students' idea progress, reflective teachers notice students' improvisational inquiry and make pedagogical decisions in response to their interpretation of important findings from students' ongoing learning in technology-mediated classroom practices (Judson, 2016; Sergis & Sampson, 2017; Viilo et al., 2018).

As a new teaching practice, teachers need to engage in student-centered noticing and reflection as co-learners: to attend to students' diverse ideas and questions in the interactive discourse, to understand how their thinking evolves in connections with core disciplinary ideas and crosscutting concepts, so as to make responsive decisions to support students' productive inquiry (Zhang, 2019). They work with students who have a high responsibility in knowledge building by following students' emergent ideas and scaffolding class discourse in line with students' ideas in progress (Zhang & Messina, 2010).

Embedded Knowledge Building Analytics for Transformative Assessment

Embedded KB discourse analytics provides students and teachers with additional aids to trace new and cross-curricular ideas in the discourse of the learning community. In this setting, students are socio-cognitive agents to build the Zone of Proximal Development (ZPD) of their learning community (Ma, 2018; Scardamalia & Bereiter, 1991).

With *agency-driven*, *choice-based*, and *progress-oriented* analytics and feedback, students play the central roles in the learning community to decide the fluid direction and focus of their knowledge building across *levels*, *units*, and *timescales* as they progressively improve their knowledge. Students are primary *epistemic agents* who contribute to collaborative knowledge cultivation of their learning community in *design-mode thinking* (Chen & Zhang, 2016). They are active knowledge creators and have a high responsibility for cognitive deepening, generating creative inquiry based on their learning need over time, and keeping track of idea progress. They explore solutions to their real-world inquiry, which can be revised as they develop progressive ideas (Scardamalia & Bereiter, 2003). In design-mode thinking, students' knowledge is sustainably improved through "theorizing, invention, design, identifying promising ideas, and searching for a better way" (Bereiter & Scardamalia, 2014, p. 38). In this sense, analytics of students' discourse in KB pedagogy enhances the understanding of how students continuously move on to the advanced and in-depth sphere of knowledge across multi-layers in terms of time and research areas while they work together to achieve their learning goals (Chen & Zhang, 2016; Scardamalia & Bereiter, 2003).

Teachers monitor students' idea progress while students are skillful in discovering promising information in the process of assessment, each of which is interdependent for improving knowledge (Boud & Molloy, 2013). However, few studies have considered learning analytics in line with teachers' noticing and responsive scaffolding of sustained improvement of curriculum design based on the examination of educational data (Sergis & Sampson, 2017). The genuine implication of conducting learning analytics in class is amplified when it supports teachers' data-driven design of pedagogy and their iterative reflection and scaffolding of classroom activities (Hernández-Leo et al., 2019). Activated real-time transformative assessment is facilitated by teachers' concurrent reflection on students' idea progress and learning experience in the classroom. Technology-assisted monitoring in students' collective learning provides teachers with data-driven evidence to discover urgent needs for making decisions on a timely tactic to enhance students' knowledge advancement and provide students with customized feedback (Chen et al., 2017; Hernández-Leo et al., 2019; Pardo et al., 2019).

Teacher Noticing and Scaffolding for Knowledge Building with Analytics Support

In light of the review of the literature above and building on the conceptual work of Zhang (2019), this paper proposes a framework of **teacher noticing and responsive scaffolding for knowledge building with analytics support.** At the center of this framework are the student-driven knowledge building processes guided by the knowledge building principles. The teacher engages in reflective noticing and responsive scaffolding aligned with student-driven inquiry and conversation in the community, as informed by KB discourse analytics. Working as co-learners and facilitators, teachers observe and notice students' knowledge building processes, attending to students'

authentic problems and collective knowledge creation in the curriculum context, in terms of *what*, *who/with whom*, *with what idea and progress.* Specifically, they trace and ponder *what ideas students are exploring*, *who are working on the ideas with whom*, and *what other ideas students are expanding and in what progress.* The noticed moments are interpreted to build responsive and strategic moves to facilitate and integrate students' sustained ideas. These processes are supported by the embedded analytic tools that foster the transformative assessment of the growing communal knowledge. Below we elaborate on the two key components of this framework related to the teachers' scaffolding: (a) reflective noticing and responsive scaffolding: Attend, Interpret, and Make Moves; and (b) analytics support for teacher noticing and responsive scaffolding in knowledge building.

Student-Driven Knowledge Building Guided by Knowledge Building Principles

Students are central agents in improving their knowledge. Working individually and collaboratively with the epistemic agency, they engage in ongoing discourse guided by KB principles (Scardamalia & Bereiter, 2010), driving the onward progress of ideas with evolving inquiries in knowledge building communities. They understand their surroundings, experience objects, and find real-world problems. Then, they explore practical solutions and take actions to resolve problematic issues (Scardamalia, 2002; Scardamalia & Bereiter, 2010).

The creation of advanced inquiry goes beyond the static state of current knowledge (Paavola & Hakkarainen, 2005). Students initiate ill-defined inquiry and build coherent lines of ideas. Taking on communal responsibility, they set up long-term learning goals and collaborate to achieve the goals (Hmelo-Silver & Barrows, 2008; Zhang et al., 2011). However, although students' work can be accomplished through collaboration with peers and supervision, a heavy emphasis lies in "sharedness and joint action of an epistemic nature" (Damşa et al., 2010, p. 180). In classroom practices, students build and adopt structures of shared inquiry to create collaborative knowledge, sustain idea improvement, and generate deeper questions (Damşa et al., 2010; Tao & Zhang, 2018). They create deepening ideas that are valuable to the community, while individual knowledge development is in line with the community's inquiry progress (Scardamalia & Bereiter, 2010). To reach high-level knowledge, they revise improvisational ideas and make their inquiry moves forward with intentional efforts to improve continual knowledge (Scardamalia, 2002; Scardamalia & Bereiter, 2010).

KB pedagogy encompasses students' pieces of diverse ideas, constructing highly-developed collective knowledge. Students synthesize their various and complicated ideas by means of *rise-above* to build a comprehensive knowledge of the communities (Scardamalia & Bereiter, 2010). They integrate ideas in different or associated areas along with emerging goals to go beyond disconnected inquiry and build all-embracing knowledge of the community (Scardamalia, 2002).

The process of knowledge building is monitored through transformative assessment (Scardamalia, 2002). Transformative assessment is embedded in the progression of students' dynamic moves in collective idea advancement. Concurrent transformative assessment improves students' metacognitive skills for self-monitoring the community's sustained knowledge building (Scardamalia, 2002; Yang et al., 2020). It then returns in-the-moment feedback to students, helping them adapt the next moves along their idea-growth trajectory (Scardamalia & Bereiter, 2010). Carrying out collaborative knowledge building activities in classroom, students assess ongoing ideas in open-ended collective discourse, build on new inquires, use supportive tools, and incorporate diverse ideas for robust creation of extensive and ever-deepening inquiries (Hmelo-Silver, & Barrows, 2008; Lei, & Chan, 2018; Zhang et al., 2007).

Reflective Noticing and Responsive Scaffolding in Knowledge Building Communities

Collaborative knowledge building of students is supported by teachers' meticulous attention to student-driven idea progress and responsive envisioning to facilitate profound inquiry creation and collaboration. In order to facilitate students' collective knowledge building, teachers conduct open-ended planning and engage in the knowledge building process as co-learners in order to catalyze productive knowledge building moves; thus, they are aware of how to deepen students' inquiry. As an essential aspect of reflective teaching, teachers are agents in ongoing noticing and envisioning to capture students' emergent inquiry and deeply muse on the noticed moments to scaffold responsive moves to foster students' deeper inquiry (Hammer & van Zee, 2006; Judson, 2016; Luna, 2018; Robertson et al., 2016). In a science inquiry designed with KB pedagogy, teacher's pedagogical envisioning is responsive to the idea progress of students in the knowledge building community (Judson, 2016). They share their noticing and thinking with students who are engaged in collaborative decision-making to advance students' collective knowledge (Zhang & Messina, 2010). Aligned with the previous relevant discussions (Jacobs et al., 2010; Judson, 2016; van Es, 2011), three components of teacher noticing and responsive scaffolding of students' collaborative knowledge building discourse are suggested: *Attend*, *Interpret*, and *Make Moves*, which all centered at students' collective and continual idea improvement (Zhang, 2019).

In KB pedagogy-supported learning, teachers *attend* to (notice) emergent inquiry in terms of who are core contributors and with whom, and with what ideas and progress. During students' inquiry practices, teachers immerse themselves in students' authentic problems in line with students' collective knowledge creation and follow their dynamic progress in exploring solutions to questions. Along with students' growing ideas, teachers pay close attention to moment-to-moment perspectives of students' individual and collective thinking to find ways of facilitating students' deeper inquiry. They investigate students' thinking in knowledge building discourse regarding what is *new* and *promising* for the facilitation (Zhang, 2019). Students' ideas, questions, and emerging idea connections are driving forces to envision the deeper inquiry of their communities.

During and after monitoring of students' collective inquiry progress, teachers *interpret* (think about) the meanings, reasons, and implications of the noticed patterns. They decode the patterns of students' behavior and epistemic development in their own words and understanding. They reflect on how students have learned, think now, and improve collective knowledge regarding the community's past and future inquiry. They translate observed critical moments into ideal scenarios for cultivating students' promising ideas in the curricular context. Accordingly, the designed idea-deepening scenarios through the teacher reflection are to *make moves* (envision possible actions) that enhances students to take action on deepening inquiry in practice. Teachers adopt various supportive strategies and tools to make the scenarios practical and contribute to the students' sustained knowledge building according to the community's urgent learning needs. The strategic moves leverage students' endeavors to advance the collective inquiry and integrate core ideas for advancing knowledge building discourse of the community (Zhang, 2019).

Knowledge Building Analytics for Teachers' Reflective Noticing and Responsive Scaffolding

Student-generated inquiry reflected in the community's knowledge building discourse is a key element to be monitored for students' communal epistemic advancement (Oshima et al., 2012). It is the shared goal for students to monitor evolving inquiry and zoom in on the spheres of the pending problems that have potentials for advancing their prospective collective knowledge. Throughout tracing promising inquiry and finding practical solutions, students' knowledge building discourse moves forward with gradually deepening ideas and dynamic interactions among students. Conducting a transformative assessment of emergent inquiry and chains of ideas, the learning community explores new gaps between current and future knowledge to reform the design for successive learning progress (Scardamalia & Bereiter, 1991).

One of the critical roles of teachers in student-driven knowledge building progress is to facilitate the transformative assessment of students' evolving inquiry and re-design and implement the lessons accordingly. Teacher noticing is intertwined with students' knowledge building discourse moves over time, while the embedded analytics support enhances teacher noticing. Through the technology-assisted cyclical assessment of the communal idea progress, teachers iteratively track emergent inquiry and discover original ideas in students' authentic knowledge building discourse. They pay attention to students' new inquiry, collaborative features, and the progress of the idea improvement concerning which ideas and with whom. The evidence of students' evolving inquiry and collaboration, derived from the analytics support, works as a resource for teachers to build reflective questions about teacher noticing and address their own needs and intent of improving teaching. Of the identified evidence in teacher noticing, teachers are the actors to evaluate its usefulness and relevance to the flow of students' knowledge building and integrate the high-quality information into their thinking of hands-on noticing on students' progress.

With the evident monitoring, teachers visualize the next step of students' collective learning as they design customized and real-time pedagogical tactics to advance, deepen, and continue the renovation of the community's knowledge (Chen & Zhang, 2016; Scardamalia, 2002; Zhang, 2019). Responsively, the evidence-based teacher reflection scaffolds the subsequent moves of the knowledge building discourse. Once responsively scaffolding the following lessons, teachers facilitate students' knowledge building in practice, which is the point where they continue to notice students' new inquiry for further reflection and envisioning. Thus, students' collective knowledge is sustainably progressive in the classroom, along with not only the community's emergent inquiry but teachers' deep thinking on that.

The authentic classroom is where students' knowledge building discourse unfolds, and students' collective inquiry originates. An essential part of teacher responsive scaffolding in classroom work is the curriculum. In reality, teacher noticing and responsive scaffolding operate through complicated processes in the authentic context of the curriculum. In the curricular context of the student-driven knowledge building process, envisioning students' sustained ideas functions with the classroom activities re-directed along with the emergent inquiry. Thus, how teachers notice and interpret students' knowledge building is interconnected with their co-engagement in students' deepening ideas in the classroom. They probe the students' idea progress from the perspectives of teachers themselves, which is guided by the standards and expectations of the curriculum, such as NGSS (National Research Council, 2013). Although the curriculum in the classroom with student-driven knowledge building discourse is not

scripted and pre-designed, teachers use the critical constructs of the curricular expectations as the focus of their ongoing noticing and responsive scaffolding of students' collective progress of the cross-cutting ideas.

In order to support the teacher noticing and responsive envisioning in the curricular context with KB pedagogy, embedded KB analytic tools are utilized. Key types of analytics that assist this process investigate multidimensional aspects of students' ongoing discourse moves in knowledge building, such as lexical use, theme clusters, contribution to the discourse, collaboration patterns, and depth of inquiry and ideas. Examples of the analytic tools in knowledge building are the functions in Knowledge Forum (KF) and Idea Thread Mapper (ITM), the online discussion platforms using KB pedagogy. Specifically, *Activity Radar* tracks students' contribution to building discourse on ITM, showing the number of cumulated notes that students read and post on ITM. It demonstrates the real-time tracking of "new posts," "my posts," "build-on to my posts," and "new highlights." *Author Network* shows the interactive relationship between students in terms of reading and building on peers' notes. Besides, *Feedback* is a function that students can use to self-evaluate their writing in terms of depth of explanation and question. It gives students immediate, responsive feedback once they click the "feedback" button, which encourages students to contribute a more elaborated idea and deeper inquiry in their notes.

Teachers use these analytic tools as needed throughout the teacher noticing process. The analytic tools inform teachers of data-driven guidance to make reflective moves for envisioning students' knowledge building discourse in the context of the curriculum. Meanwhile, based on teacher reflection, teachers encourage students to use these functions as transformative assessment tools for building more profound ideas with peers. Students monitor their knowledge building progress and receive immediate feedback for deepening their inquiry. All these noticing and transformative assessment processes occur iteratively, revolving around student-driven collective idea progress in the curricular context using KB pedagogy.

Discussion and Conclusion

A critical idea delivered in this paper is that to improve the learning environment with student-driven collaborative inquiry, teachers need to co-engage in students' inquiry progress. Learning analytics supports this process with data-driven evidence. Grounded in the literature, the present paper discussed teacher reflection in open-ended, collaborative knowledge building discourse and embedded learning analytics to support teacher noticing and scaffolding. Aligned with the teachers' noticing, interpreting, and making moves in students' collective inquiry progress (Zhang, 2019), we proposed a framework of embedded analytics support for reflective noticing and responsive scaffolding in knowledge building communities.

To discuss the conclusions, we first argue that teacher noticing traces the growth and change of students' progressive inquiry to implement responsive course designs in the classroom and redirect the following progress. Teachers need to deeply comprehend how students participate in idea progress in the authentic classroom practices and design responsive lessons in line with the community's inquiry progress (Greiffenhagen, 2012; Jacobs et al., 2010). More importantly, teacher noticing and scaffolding should be implemented in evolving inquiry of the knowledge building communities. It goes along with individual and collective students' ongoing ideas and emergent inquiries for further fostering collaborative work and sustained idea expansions over time.

Our next argument is that analytics support should assist teacher noticing of student-driven collaborative inquiry with evidence derived from knowledge building discourse. The knowledge building analytics mines students' enormous ideas in ongoing discourse and figure out critical inquiry moves appearing in the current, dynamic discourse. This analytics assistance is helpful for teachers' reflective noticing since it notifies teachers of veiled phenomena in students' collective knowledge building progress that is hardly seen by teachers' naked eyes. The analytics support digs into the deep inside of students' collaborative inquiry moves, gets to the core point of the ongoing discourse, and brings the finding to the surface. Then, the finding is provided to teachers so that they can adopt it as analytical feedback.

Our above arguments resonate genuine adoption of learning analytics in the learning context where students' collective inquiry is a critical object and teachers co-work with students. In principle-based collaborative learning, students' inquiry progresses with new inquiry over time, and so does students' collaboration pattern is. Additional support is needed to promote teacher noticing in the classroom, helping teachers figure out emergent inquiries in ongoing collaborative discourse of the knowledge building communities. Nonetheless, it is challenging to provide teachers with in-the-moment feedback about students' inquiry progress and collaboration patterns, which is due to fact that the nature of teachers' noticing and scaffolding is as complicated and dynamic as students' inquiry progress.

Future research should tackle these issues in supporting teachers' reflective noticing and responsive scaffolding with analytics support. It first investigates the mechanism of teacher noticing and scaffolding in student-driven knowledge building communities and then implements the uncharted mechanism in the classroom with the

additional support of knowledge building analytics. In particular, further study should examine multidimensional elements derived from students' collaborative, ongoing discourse and test the usability of the examination as analytical feedback to support teachers' concurrent noticing. All these investigations need to be conducted cyclically in the curricular settings in the classroom. This way may serve researchers in the field better understand how teachers monitor and envision students' collaborative knowledge building in the authentic classroom and how learning analytics supports this process.

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Optimising Alterity: A case for the Knowledge Forum.

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Abstract: Through the phenomenographic lens, consideration will be afforded to the pedagogic framework of informed learning (Bruce, S. C., 2010) through which learners are enabled to utilise information to learn through variation in a self-established relational frame. The concept considers the aspects of '*Alterity*' that exist within the cohort of study. Building upon the works of Goldstein, Webster and Whitworth (2008, 2009, 2014, 2016, & 2017) aswell as specific authors in associated areas, such as Chaordic Learning, and the Triadic Learning Environment, the paper seeks to evaluate ways in which such points of difference can be optimised for the benefit of enhanced information literacy and overall levels of attainment.

Keywords: Alterity, Chaordic learning, Information literacy, Informed learning, Triadic learning environment.

Introduction

The changing face of teaching has moved away from predominantly didacticism to a more Socratic perspective of learning facilitation and with this is the need for teachers to play different roles and use new techniques (Griffin, 2002, Jarvis, 2002). Rogers (1989) relates the need to break away from one-pace teaching to use flexibly-paced, multi-resourced learning strategies, also by setting clear objectives and ensuring that everyone meets these using a set standard to indicate achievement.

Learner engagement in the sharing of their experience brings richness to the learning experience if appropriately scaffolded. This paper offers consideration to research within the area of optimising alterity to improve the learning and overall Learner experience whilst studying upon a blended learning, part-time, Level 7 apprenticeship programme. Apprenticeship programmes of this nature allow Learners to remain within full-time employment working alongside experienced staff (which is an integral part of and facilitates the triadic learning environment), whilst earning a wage and gaining relevant work-related skills. The funding for such programmes is provided by the UK Government via a Levy funding model of taxation upon businesses and is strictly monitored and controlled by the Education and Skills Funding Agency (EFSA). A major component of the apprenticeship funding rules is that employers must allow 20% of the Learners contracted hours to be utilised for Off the Job training towards the programme of study. In addition, an appropriately qualified 'Work-based Mentor' is required to be appointed to support the Learner through their apprenticeship journey in areas such as the supervision of the Off-the-job training allocation and the contextualisation of the Knowledge attained on the programme into the workplace environment to develop innovation and change.

The paper considers opportunities to develop andragogic practice and programme design within the Higher Education setting, through the study of student discourse appropriately supported by tools such as the Knowledge Forum. As Learners are engaged within full-time employment, there exists the opportunity for enhanced application and contextualisation of subject knowledge through a process of Triadic Learning. However, it needs to be recognised that Learners on this programme are usually senior managers who have considerable pressures upon their time within the work-place. The predominant demographic characteristics of Learners is such that the vast majority have family commitments also calling upon their time. Therefore, elements of the apprenticeship programme need to consider such time constraints and ensure that all elements of the programme design are achievable within strict time constraints.

Consideration will be afforded to the difference in terms of degree of Alterity, between the experience of Learners within both Single and Multi-organisational cohorts. Applications such as The Knowledge Forum will be considered in supporting this process moving forward. Soliman, D. (2021), highlights, Knowledge Forum is designed to make transparent and accessible means by which deep understanding and sustained creative work proceed.

Learners within each cohort join the programme with varying degrees of alterity formed through differing demographic profiles in terms of age, educational attainment, experience within the workplace, role and responsibilities, sectors within which they are employed and education attainment. Bringing these factors together, appropriately supported through a process of scaffolding seeks to facilitate creativity of thought and enhanced learning through the richness of alterity within the Cohort.

Learning Opportunities

The current programme offers faculty led tutorials which consolidate knowledge attainment attained through a '*Flipped Classroom*' approach to study. As defined by Lage, et al (2000), "Inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa" (p.32).

In our specific case, learners are encouraged to undertake reading and research into the subject area prior to developing ideas and concepts through cohort tutorial sessions led by the Unit Convenor (Lecturer).
Following a process of reflection upon the tutorial, Learners attend a face-to-face tri-monthly workshop session where they have the opportunity to explore aspects of the module in a series of cohort-wide group work sessions.
Assessment of the Module is then undertaken by way of a reflective practice paper within which Learners consider the main concepts, theories, models and theorists outlined within the module and contextualise the same into the workplace environment. The activities outlined are supported by online discussion forums within the Virtual Learning Environment within which, through a process of scaffolding, Learners are encouraged to share their understanding of the theory, and its application to a workplace setting.

Given the degree of alterity that exists within each cohort, this shared learning experience has the potential to contribute to a wider understanding across various organisations and sectors. Whilst discussion forums are provided by the University, Learners are also encouraged to develop collaborative platforms to support and enhance their learning.

In reality, this aspect of the programme is flawed. Flawed for two primary reasons:

1) There is insufficient focus placed upon this important aspect of the pedagogic diet by faculty members to ensure that appropriate scaffolding and supportive feedback is provided to facilitate the proactive engagement by Learners,
2) Learners are not proactive, perhaps due to 1) above, in engaging with this resource especially when they are under time constraints.

Consideration of the Knowledge Forum to enliven this specific aspect of the programme could, encourage knowledge building discourse according to Soliman, D., 2021, "Knowledge building discourse happens in "design-mode", where the main concern is with the "usefulness, adequacy, improvability, and developmental potential of ideas".

Learner's Initial challenges & limitations

Learners face a variety of challenges when joining a higher level apprenticeship programme. Programme evaluation data common highlights the following areas which impact negatively upon Learners and their attainment and retention on programme.

Imposter Syndrome: Imposter syndrome often exists within Learners who traditionally have not studied at the Higher education level previous, or for whom such study is a dim and distant memory. The concept involves anxiety in relation to self-doubt and lack of confidence that persist despite the level of education, experience and achievements to date. Mullangi, S. and Jagsi, R. (2019) highlighted how the syndrome disproportionately affects women and minority groups—who often lack sufficient role models of success.

Lack of familiarity with cohort members and the study/learning environmental: Bringing together any new grouprequires a period of introduction, induction, and familiarisation. This relates not only to the Cohort members themselves, but faculty and support staff, the academic environment be that physical or virtual and the various systems, protocols and procedures contained therein. This brings to mind Bruce Tuckman's Group Formation theory (Tuckman, B., 1965). Tis model is relevant in these circumstances as it recognises the fact that groups do not arrive fully-formed and functioning. Tuckman suggests that groups grow through clearly defined stages from a collective of individuals, through to cohesive task-focused teach. A process, that it could be argued reflects the Chaordic Learning theory of identifying growth and learning from chaos when overlaid with order.

Inexperienced with communications channels and programme software: Time as a factor has already been mentioned earlier within this paper. Frequency of use of the various communications channels and programme software is the key to building confidence and competence with such media. Often learners within the apprenticeship programmes lack the capacity of time and prefer not to engage with such systems due to the lack of time to gain a working confidence. The investment of time, over the initial period of the programme has proven through programme attainment data to pay dividends in terms of programme engagement and general understanding. This does however identify the point that any system(s) considered for the measurement of Learner discourse will need to be introduced with the appropriate system support network to ensure appropriate levels of engagement.

Limitations of study habits and understanding of Information literacy: As mentioned earlier, many Learners arriveat the programme with either no previous experience of studying at the Higher Education level, or it has been many years since they have done so. As such, study skills and study habits and routines are quite often at a fairly low level.This is particularly relevant when you consider the demographic profile of the average Learner who is most likely tobe a middle manager, with considerable workplace responsibilities as well a person with a family. Each of these factors placing considerable pressure upon the time available for study and learning. Information Literacy (IL) playsa key part in the apprenticeship programmes of study. IL was original defined by the American Library Association as " . . . a set of abilities requiring individuals to 'recognise when information is needed and have the ability to locate, evaluate and use effectively the needed information" In essence, this description seeks to identify IL within the studyskills field. Taking this to the next level Whitworth, A (2012) describes: "*The shift in perception, from librarians asproviders of information to librarians as educators in the effective use of information, requires the profession to become aware of differing approaches to the development of teaching and of the professional consciousness of educators: also of the way certain forms of teaching and CPD are privileged over others within higher education institutions, and why."* Whitworth within his paper makes a series of recommendations for advancing the field of information literacy including enhanced, ongoing continuing professional development within the field for educators,as well as the process of continual investigation of an evolving process which needs to be informed by the evaluation of practice. It is such evaluation of practice that the proposed research '*Optimising Alterity*' seeks to undertake.

Issues identified include, but not limited to, a lack of . . .

In order to facilitate the process of '*Optimising Alterity*' a set of key characteristics are required. These include, but are not limited to the following:

Knowledge sharing: As the cohort forms and works its way through Tuckman's Group Formation Model, trust and confidence is acquired in order to facilitate Knowledge Sharing, a process whereby the cohort engages in knowledge (information, skills, expertise and perhaps most importantly experience)transfer occurs. The purpose of this exchange being to build upon the collective knowledge of the Cohort in order to create new (public) knowledge and newly created cognitive artifacts. This process is based upon Jean Piaget's epistemological theory of '*Constructivism.*'

Peer support: Peer support is imperative in supporting the knowledge sharing activities required within and throughout the apprenticeship programme. Based on the '*Community of Practice*' principles developed by Jean Lave and Etienne Wenger (1991), Learners need to come together for the common good and proactively participate in a process of creating new knowledge through the sharing of their relevant workplace 'lived' experience.

Reflexivity: In order to demonstrate *Reflexivity*, members of the cohort must be able to examine their own feelings, reactions and motives and how these elements impact upon what they think and the actions that they take in a given situation. In epistemology, and more specifically, the sociology of knowledge, reflexivity refers to circular relationships between cause and effect, especially as embedded in human belief structures. Being self-reflective, as well as sharing of reflexive experiences within the Community of Practice can lead to greater understanding of causational motivations within the workplace.

Criticality: One of the key pillars of Information Literacy is Criticality which represents the highest level of reflection. Using and questioning information rather than simply accepting, absorbing and describing it, is a vital skills not only within the field of academia, but also holds significant relevance within the workplace. Being critical supports an appreciation of the broader picture locating ideas within a wider context in an effort to develop an understanding of the causal links that exist.

How this contributes to the Knowledge Building Process?

Informed Learning: Originating from a programme of phenomenographic research in the field of Information Literacy, Bruce, S.B. and Hughes, H., (2010) describe Informed Learning as "*a pedagogical construct attending simultaneously to information use and learning.*" A process applicable in academia, the workplace and community settings, this definition sits happily alongside that of Knowledge building; 'the creation, testing and improvement of conceptual artifacts.' Informed Learning as a concept relies heavily on reflection as a strategy for initiating and generating learning.

The Triadic Learning Environment: The apprenticeship programme by its structure and as highlighted within theFunding Rules requires a Commitment Statement to be entered into between the Employer, the Learner and the Education Provider. According to the UK Government's Apprenticeship Funding Rules, "*The Commitment Statement is a statement held by the main provider, the apprentice and their employer. The commitment statement sets out how the apprentice will be supported to successful achievement of the apprenticeship. It must be signed by the apprentice, their employer and the main provider, and all three parties must retain a current signed and dated version*." (Apprenticeship funding rules and guidance for employers August 2021 to July 2022, 2021 pg. 86) The funding rules also outline the requirement of employers to engage in mentoring. The rules define mentoring as "*To include in off-the-job training, mentoring must impart new learning to the apprentice directly linked to the achievement of the apprenticeship by a more senior or experienced member of staff.*" (pg. 92). Hence the impetus for the creation of a Triadic Learning environment.

Dalrymple, R. et.al. (2014), describes Work-based Learning (WBL) as a "*triadic learning endeavour in which student, work-based facilitator and university tutor are engaged in a mode of learning which is best conceived as 'academy-aligned' rather than 'academy-based', and in which the signature pedagogic principle is one of 'responsive facilitation'* ".

In the case of the Apprenticeship programme, Quarterly Review Meetings are held between the Learner, the Work-based Mentor and the Practice-based Tutor in order to discuss elements such as the contextualisation of theory into the workplace as well as elements of programme design, such as the subject and detailed elements of the Learner's Work-based Project (Programme Dissertation), and the potential impact this research may have upon the Learner, their Department and the wider Organisation. An area for consideration is that of access to any systems to be employed by the Learner that contributes to and facilitates their Learning process. The precinct has already been established with Work-based Mentors currently having restricted access to the certain areas of the E-Portfolio system used by theLearner to monitor their progress and the development of their work-based portfolio of evidence for final assessment.Expanding this further to include access to any system employed to facilitate enhanced student dialogue presents various ethical issue. However, with appropriate limitations of access, consideration may be given to a channel of operation between the Learner, the Work-based Mentor and the Practice-based Tutor in order to include the workplaceperspective.

Chaordic Learning: Chaordic is defined by the Oxford English Dictionary as "The combination of elements of both chaos and order." (Collins English Dictionary | Definitions, Translations, Example Sentences and Pronunciations, 2021).

Chaordic Learning is a concept which was popularised by Frans van Eijnatten and Goran Putnik in and around 2004 within their publication of Introduction Chaordic systems thinking for learning organisations.

For the purposes of the proposed study, the chaos will be defined as the representation of the multitude of elements which comprise the 'alterity' of the cohorts within the sample. The elements of order will include the specific structure and its various elements of the Programme design including the tools used to monitor Learner discourse.

The apprenticeship programme is delivered via the blended-learning process. As a result of the COVID-19 pandemic and greater number of the programme activities have been placed online. Any system that supports the Knowledge Building experience therefore needs to be available within both the physical and virtual spaces and will be utilised to support and develop a strong, cohesive and dynamic learning community within which the knowledge building activity is co-created by faculty and cohort members alike. It is anticipated that the Knowledge Forum has the potential to bring order to the chaos represented by the variety of learning resources currently employed. At this juncture, the aspect of power relationships and hierarchies have not been considered in detail. However, just as within the Community of Practice model where power is vested in the core-dwelling old-timers versus the legitimate peripheral participants, Van Eijnatten's (2003; 2004) work on Chaordic Systems highlights that power relationships are present within Chaordic Learning Systems also.

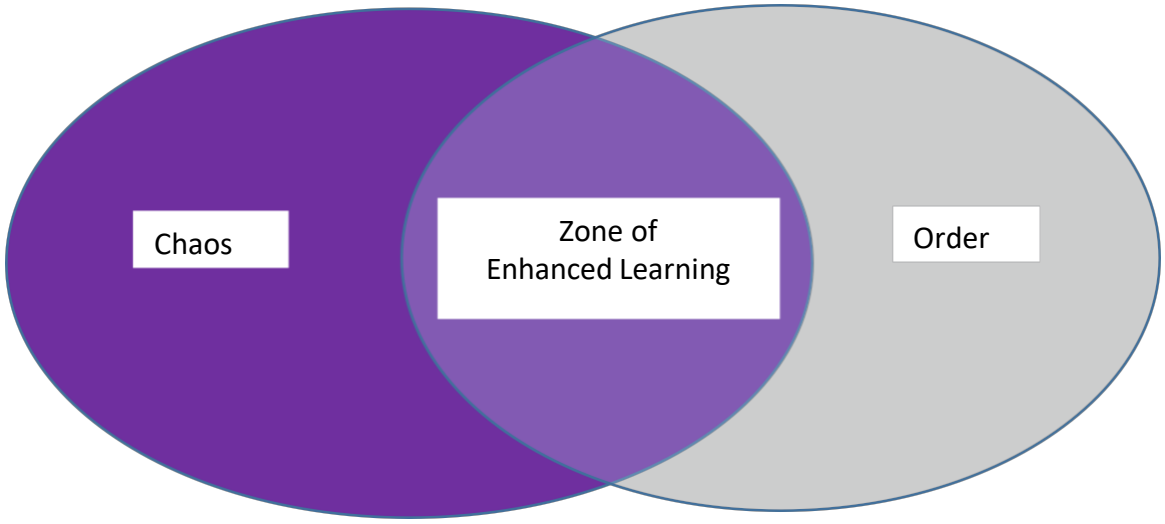

Figure 1: Chaordic Learning
Bringing together '*Chaos*' and '*Order*' to
enhance learning and growth

Conclusion

This paper has set out a range of challenges faced by Learners entering onto a Higher-Level Apprenticeship Programme within the United Kingdom, with due reference to the Apprenticeship Standards and their associated Funding Rules.

Opportunities exist to optimise the '*alterity, otherness and diversity*' brought to the programme by members of the Cohort. Diversity is evident in respect of members' age, educational attainment, experience within the workplace, role and responsibilities, sectors within which they are employed and education attainment.

As highlighted in Webster, L.; Whitworth, A. (2017), '*The learning task allowed dialogues to take place that enhanced the quality of alterity and as a result, allowed students to experience different perspectives on a phenomenon, to have their reaction to these different experiences validated, and to use this dialogue to collectively create a learning community that was oriented to them fulfilling instrumental goals.*' Employing a process such as the Knowledge Forum would potentially further enhance and validate this experience.

The creation new communities from existing cohorts, where Learners are determined as both producers and consumers of knowledge are based on connectivity and collaboration. Importantly, there is still a need for a facilitator, or knowledgeable other, in this environment to facilitate the journey that the 'others' in the system (Learners in this instance) are likely to encounter. Connectivity, where learning consists of connected 'nodes' is essential to the collaboration and expansion of knowledge, with learning occurring both within and beyond the singular mind accounting for the connected and virtual digital space that is more prevalent in Higher Education today.

Key concepts of Informed Learning, the Triadic Learning Environment and the process of Chaordic Learning have been outlined. All of which could be supported by an enhanced process of Knowledge Building. The Knowledge Forum seems ideally placed to play an important part in this initiative whilst contributing to the Innovation Network of Knowledge Building.

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Knowledge Building and Computational Thinking: Exploring Models and Simulations Across the Curriculum

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Abstract: Computational Thinking is defined as a set of concepts, skills, and practices required for students to understand, use, analyze, and create computational tools. One way to support computational thinking is by engaging students with modeling and simulations, particularly when integrated with STEM subjects. In this paper, we explore how three elementary school teachers engaged their students in knowledge building discourse around simulations in Math, Science, and Engineering. We present teachers', researchers', and students' reflections on how simulation work can be used to extend both computational thinking and subject-matter knowledge. We conclude by discussing future work on how Knowledge Building can enable young students to collaboratively engage in solving real problems via computation while advancing community knowledge.

Introduction

Among the list of 21st century skills appearing in curriculum documents (e.g., communication, collaboration, critical thinking, creativity), computational thinking might be considered one of the few skills that is truly novel and necessary for today's digitally connected classrooms. In 2006, Wing asserted that computational thinking "involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science." (p. 33). The skills and practices required for this problem-solving process include problem abstraction and breakdown, reasoning, algorithm generation, and solution verification and evaluation (Barr et al, 2011; Sengupta et al., 2013; Weintrop et.al, 2016; Wing, 2006). In today's technology-rich environments, it is increasingly important to provide students with opportunities to constructively manipulate computers and other digital tools to explore problems of understanding across different subjects (Digital Promise, 2021).

Over the last decade, a variety of approaches have been used to integrate computational thinking into K-12 classrooms, with a central focus on acquisition of skills and practices through coding and programming activities (Brennan & Resnick, 2012; Kafai et al, 2019; Kafai & Burke, 2017). However, as Bereiter (2020) cautions, "programming activities by school students [tend to] develop craft knowledge of programming but little disciplinary knowledge, knowledge of gaming or whatever art is involved, or higher-level computational thinking" (p.166). This perspective is aligned with Papert's (1980, 1987, 1993) vision which emphasizes the centrality of the learning culture and social interactions – rather than the technology itself– in the knowledge-construction process associated with computer programming. Indeed some researchers have proposed alternative approaches to computational thinking such as "systematic computational thinking" (Michaelson, 2018) and "creative computational problem solving" (Chevalier et al., 2020) which focus on developing competencies beyond the cognitive skills required for coding and programming. Others have suggested different curricular approaches to computational thinking, such as *situated computational thinking* (Kafai et al., 2019) and *computational action* (Tissenbaum et al., 2019) – which focus on social and creative dimensions of computational thinking. The current study builds on these latter set of ideas where collaborative problem solving with computational tools can help bootstrap students' work with abstract ideas toward deeper understandings. Toward this end, we propose using a Knowledge Building approach to advance computational thinking and shape students' understandings and interactions with computational models as well as their interactions with peers in their community.

Knowledge Building, Design Mode, and Modeling

Knowledge Building is an educational approach that engages learners directly in creative work with ideas through collaborative discourse aimed at advancing community knowledge (Scardamalia & Bereiter, 2003, 2006). Knowledge building discourse takes place in a 'design-mode' where students are inventing and theorizing at the edge of their understanding and exercise epistemic agency to set learning goals and sustain idea improvement (Scardamalia & Bereiter, 2003). Knowledge Forum (KF) technology is designed to support knowledge building discourse, with

features such as theory-building scaffolds, which can help frame students' thinking and make their ideas more concrete.

Similarly, computational thinking requires dealing with abstraction through design thinking (Wing, 2006, 2008), with models and simulations as one way to support computational practices and attitudes (Barr et al, 2011; Sengupta et al., 2013; 2018; Weintrop et.al, 2016; Wilensky et al., 2014). For example, in developing computational models, students engage in design processes of identifying the components and relations in real-world phenomena and undergoing iterative cycles of model evaluation and refinement to generate more sophisticated and coherent explanations of the phenomenon (Sengupta et al., 2013). Therefore, productive use of computational models during Knowledge Building has the potential to sustain and advance community knowledge in multimedia rich environments.

The synergy between Knowledge Building and modeling offers promising opportunities for teachers to design learning environments that enable students to explore abstract concepts and enact different forms of agency. As students initiate their knowledge building discourse (e.g., theorize, ask questions, and build on each other's ideas), computational models can then be introduced to visualize and test ideas in the community. As students deepen their inquiry and consult more authoritative resources, they may refine their theories, realize that certain aspects of the model are missing or that a model is not an accurate depiction of a phenomenon. At advanced levels, students can create their own models using agent-based modeling tools, such as Star Logo (Resnick, 1996) orViMap (Sengupta et al., 2015) or even code their own models to address problems of understanding wherein programs become "incubators of powerful ideas" (Papert, 1980, p.126). Models are in turn objects of discourse and reasoning with complexity and uncertainty in the Knowledge Building community.

Current Study

Computational thinking is increasingly viewed as a concept that can be integrated with a wide range of disciplines rather than a standalone subject (Lee et al., 2020; Sengupta et al., 2018; Weintrop et al., 2016; Wilensky, 2014). In Ontario, computational thinking was recently added to the Science, Technology, and Math curriculum (Hennessey et al., 2017; Ontario Ministry of Education, 2020) which has provided teachers with opportunities to test new tools and practices for developing this new set of skills in the classroom. For example, according to the Ontario Ministry of Education (2020), it is expected that by the end of grade 6, students will be able to "solve problems and create computational representations of mathematical situations by writing and executing efficient code, including code that involves conditional statements and other control structures" (p. 357). The challenge for the Knowledge Building teacher is to design learning environments where productive use of computational tools and models can deepen students' engagement with big ideas across the curriculum.

The current study addresses the following problems of practice: 1) How can we use simulations, animations, and coding in service of Knowledge Building? and 2) How can knowledge building discourse around computational models advance computational thinking? In this pilot research, we explored the different ways in which three elementary school teachers in Ontario have integrated computational modelling into their classroom practices during the winter term of 2021 (January to June). Because there was an abrupt provincial school closure in March 2021, teachers had to shift to emergency remote teaching without much notice or preparation. Therefore, classroom designs were adjusted to meet immediate needs of teachers and students. In the following sections, we present preliminary findings from teachers' initial design iterations around working with simulations, as well as students' reflections around the computational tools. In the first example, Ben used simulations in grade 6 science to study concepts related to natural selection. In the second example, Mike used animations in grade 3 engineering to study concepts related to forces and structures. In the third example, Darlene used coding in grade 6 math to engage students in creative computational problem solving.

Simulations in Grade 6 Science

Ben is a sixth grade teacher at the Dr. Eric Jackman Institute for Child Studies. In his pilot design, Ben was interested in how simulations could be used to help his students visualize abstract scientific concepts related to evolution. Students engaged with an interactive Phet simulation (Perkins et al., 2006) on natural selection. The simulation allows students to explore the interplay between traits and mutations of populations of bunnies, selection agents like predators, and environmental conditions. Students can reason about and test ideas around how different traits and factors affect population growth or decay. Students can modify behavioral rules to see how the system behaves. Figure 1 highlights key features of the Phet simulation, with a population graph showing population change over time relative proportions of traits and the pedigree chart of the bunnies. Over the course of two Zoom sessions (one hour per half group), Ben invited students to try the simulation and share their ideas and discoveries with the rest of the class. Student discourse was transcribed and coded for ideas about evolution and reflections around the simulation tool itself.

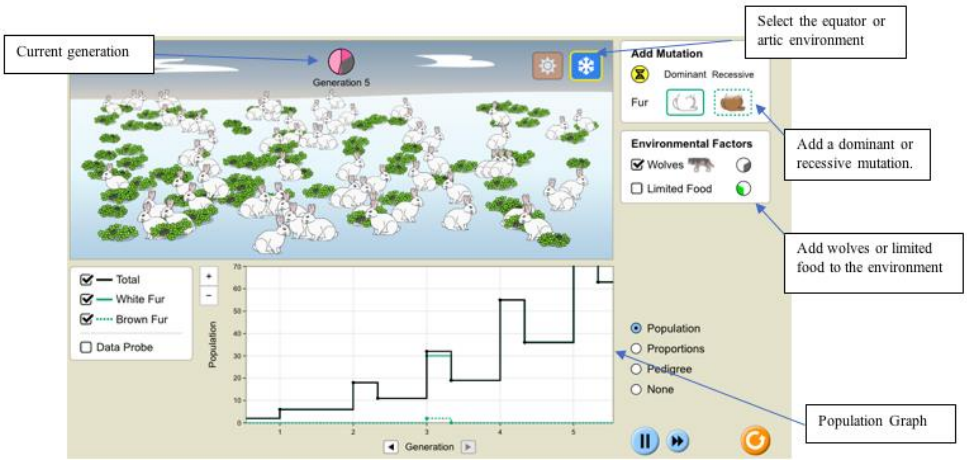

Figure 1. Phet Natural Selection Simulation.

Student Discourse

Students were actively theorizing and predicting while working with the simulation. They provided explanations on how and why the simulation would behave in a certain way when certain variables were changed and provided explanations for the outcomes they observed. For example, one student wanted to test their theory; "I'm going to wait till there's a lot of bunnies and then I'm going to do limited food, and they'll be like fighting over food"." Another student explained that all their bunnies were brown because they "finally got them to evolve'.

New ideas emerged organically as students were observing and experimenting with the simulation and building on each other's ideas. For example, the excerpt below highlights concepts related to balance in the ecosystem and the roles of dominant and recessive genes during natural selection:

S1: I got the perfect amount of each.
S2: I kept on adding and taking away the wolves and kept it on the sunny part because it starts as a white bunny and then I added the brown bunny so that it could be balanced.
S3: I think the way to make it balanced is to make the brown bunnies dominant…because then they breed. Because I noticed if the brown bunnies are recessive then they only breed brown bunnies for me.
Ben: Yeah this is the question of dominant and recessive...
S4: I can explain... If you have a dominant trait and a dominant trait breed together, then the offspring will have that dominant trait. Same with the recessive. If recessive and dominant traits breed together then the offspring will have that dominant trait but will be able to pass on the recessive trait.

Other concepts that emerged include how the rate of evolution is affected by different factors in the ecosystem, such as food, predators, and weather. Students discussed how long it took their generation of bunnies to become extinct and discussed their theories around this. For example, one student explained that bunnies did not evolve fast enough and that there were not enough genes to spread to all bunnies, which opened up further discussions on how some species cannot adapt fast enough to changes caused by humans in the environment.

Student Reflections

Although students were not directly prompted to critique or improve the design of the simulation, some students highlighted conceptual issues they found with different elements of the simulation. For example, one student wondered why the simulation specifically used bunnies and not another type of species, because some bunnies change their fur color according to the season. Another student asked if the simulation tracked the evolution of wolves as well as bunnies. These observations show that young students can analyze simulations in terms of 1) the choice of the simulation agent as the unit of the model design, and 2) whether the simulation tracks the behavior of single or multiple agents.

Taken together, these observations illustrate how collaborative discourse and hands-on experimentation with simulations can help advance students' scientific understanding. Additionally, this combined approach can help

advance students' computational thinking competencies, as students engage in using and critiquing models, and practice algorithmic thinking as they trace the steps that lead to a particular behavior in the simulation.

Animations in Grade 3 Engineering

Mike is a third grade teacher at the Dr. Eric Jackman Institute for Child Studies. In his pilot design, Mike was interested in using digital simulations to enable his students to test their theories and hypotheses about forces before building physical bridges, with the intention of setting up an in-class "testing station" to record experiments and run simulations. In particular, Mike wanted to use simulations to help students understand the concepts of stability and strength in structures and how different forces such as tension and compression can affect them. Figure 2 shows the bridge simulations embedded in Knowledge Forum. These simulations allow students to select a type of bridge, and then manipulate the bridge to see the distribution of forces and to identify parts of the bridge undergoing tension (stretching–pull force) and compression (squeezing–push force). Over the course of a few weeks, students engaged in discussions on Knowledge Forum (Figure 2). Prior to using the simulation, students contributed 74 notes with their initial ideas and theories. After using the simulation, students contributed 30 notes to share their reflections and new understandings. Below, students' initial ideas are presented, followed by their improved ideas.

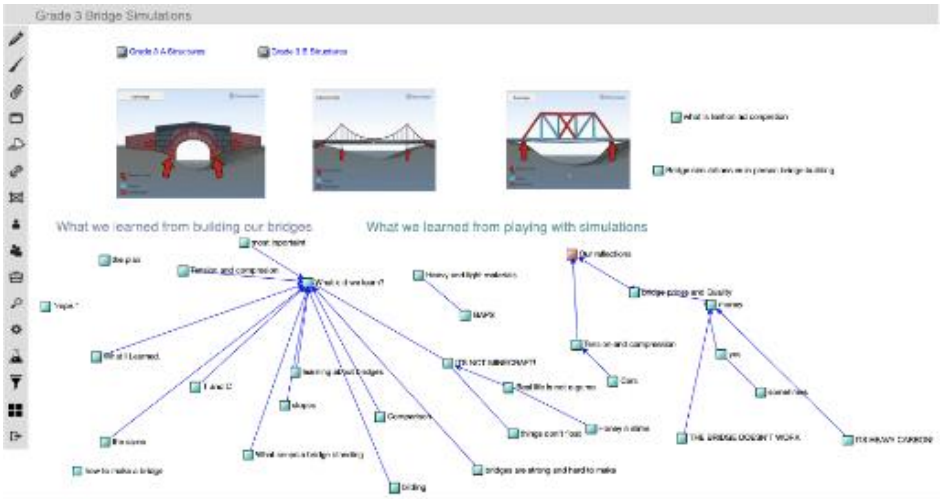

Figure 2. A Knowledge Forum view with students notes discussing structures and simulations.

Student Discourse (Before)

Question #1: What is a structure, do they need to be physical? Almost all students who responded to this question believed that structures can be physical or abstract. A recurring theory posed by students is that 'ideas' also count as structures. Other understandings on properties of structures emerged from student discourse. For example, students discussed whether or not moving objects are considered structures, and some theorized that some structures can occur naturally, such as mountains and caves.

Question #2: What makes a structure strong? Two main ideas were discussed in response to this question. First, students believed that specific types of materials, such as bricks, make structures strong. Second, students highlighted the importance of a solid base or foundation for making a structure strong. Interestingly, four students explained that strong structures need "compression" – although the term was used without any explanation.

Question #3: What makes structures the same or different? Students discussed how structures are different according to their shape, size, and materials they are made from. One student pointed out that different structures can have different purposes and provided buildings, trees, and roads as examples. One student wondered about safety in structures, which led to more discussion around the importance of testing and inspecting structures.

Student Discourse (After)

When discussing the concepts of bridges, several students highlighted the relationship between the cost and material required for building strong bridges. Other students highlighted the importance of planning, testing, and continuous redesign to improve structures. One student in particular used specialized terms like "blueprints" to describe why testing is needed to ensure bridges are able to withstand different forces: "Many architects make blueprints before

actually MAKING the bridge so that they can test it to make sure that it is stable enough to withstand tension and compression". Students also used the terms "compression" and "tension" more purposefully than in their initial conversations, and explained that bridges should be built from material that can "withstand tension and compression."

Student Reflections

After playing with the simulations, Mike facilitated a discussion with his students around the benefits and limitations of simulations. One student explained that simulations are harder because you are not actually working with the real material, while another student argued that simulations are easier because you can remove parts you do not need. One student acknowledged both the strengths and limitations of the bridge simulation: "They are hard because they cannot be tested in real settings, but are good because they don't require the purchase of actual materials." Students also reflected on how the simulations helped them understand how forces act upon bridges. One student described how the simulation allowed them to prove their theories:

> S: [My theory:] is that if a bridge is sloped then the weight is completely pushing down on the bridge so it can hold more weight. (I should try that on my physical bridge.)
> S: [My theory:] is proved because of the simulation on the screen.

Teacher Reflections

According to Mike, students enjoyed the hands-on activity and working with simulations helped them understand core scientific concepts. They were also able to think more critically about the use of simulations in everyday life:

> "I think the kids found it cool to see how the simulation could show compression and tension. When I asked what the benefit of the simulation was, some responses were: it is cheaper than actually building a bridge that might not work; it wastes less materials and time to test it out this way; it can save people's lives so that a weak bridge is not built. I then asked the children to consider these simulations as they planned/sketched their own bridge plans and when they went to build their own... It has been pretty exciting for them and they have loved testing out different ideas."

These observations, reflections, and analyses suggests that young students are able to work with simulations productively to improve their theories and address design problems using multiple parameters (e.g., cost, material, quality). Additionally, students engaged in planning, testing, debugging, and evaluation – all of which are key computational thinking practices.

Coding in Grade 6 Math

Darlene is a sixth grade teacher at Halton Catholic District School Board. In her pilot design, Darlene was interested in how coding could help students express their ideas creatively and engage in collaborative problem solving. Toward this end, Darlene offered her students the option to create coding games on the platform of their choice. While the majority of students chose to use Scratch (Resnick et al., 2009), other students chose to use code.org, MakeCode, and Flowlab – one student even decided to challenge himself by using Python. Because it was the first time for many students to try coding on their own, Darlene created a failure safe environment for them to test their ideas and encouraged students to provide positive and supportive feedback for one another on Knowledge Forum (Figure 3). Prior to designing their games, Darlene reviewed key mathematical concepts with students, such as input-output variables and shared video tutorials on how to code basic features on the various platforms. Students contributed 61 notes to share their feedback and reflections on each other's games. Below is a brief summary of students' suggestions for improvement as it relates to their intuitive theories of what makes a fun game.

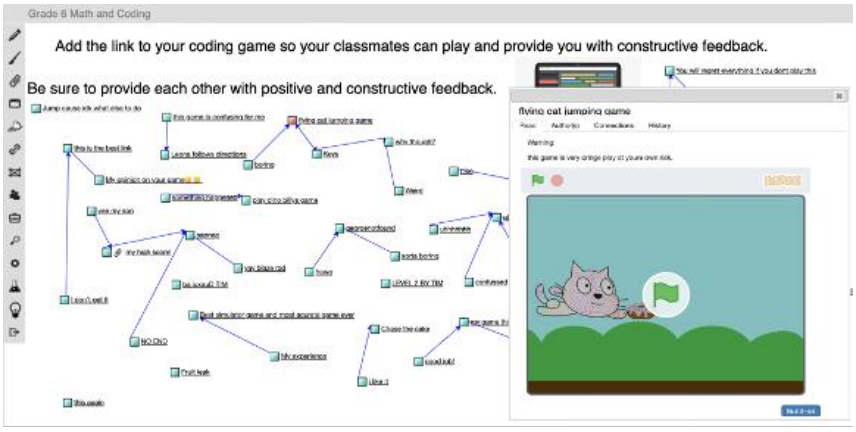

Figure 3. A Knowledge Forum view with student-created coding games embedded in notes.

Student Discourse

Students' games showed engagement with different computational concepts such as conditionals, sequences, and loops (Brennan & Resnick, 2012). There were jumping games, catching games, snake games, treasure hunt games, and so forth. Students had intuitive notions of what made a game fun, such as humour, originality, and the element of surprise. For example, one student explained how incremental challenges can make a game more fun and provided the following suggestion for improvement: "My experience with this game is good, but the obstacles are too repetitive and predictable. Maybe you could make multiple levels after a certain amount of jumps completed."

With other games, students helped debug issues related to the animation speed, rotation, and velocity of their sprites. One student pointed to the tradeoff between speed and accuracy: "Maybe you can make the character run faster, so the movements would be smoother. I figured it was hard to catch the gem in such slow pace." In another exchange, one student suggested to another student how to improve the user experience of her game by considering the placement of the gamer's fingers and ease of control when playing the game:

S1: You should change the key for flying up with "w" and the other key should be "c" or something.
S2: Why? Is there something wrong with the controls?
S3: Your fingers are in a weird position when you're playing the game.

Teacher Reflections

According to Darlene, students had a lot of fun coding their games and were proud of each other's games in spite of the bugs they encountered:

> "I had fun playing them and some of them added voice to it as well which was kinda cool! Because it was our first time coding, I suggested using code.org and Scratch, but they're the ones who suggested Python and MakeCode!… I said, "Sure, why not?" but it turned out to be pretty complex for grade 6. It was a shame we didn't get as far as we wanted because of the lockdown after the break. But the kids helped a lot – we reflected on what worked, what didn't work, and what could have been better."

This set of reflections suggests that when a continual improvement approach is taken to teaching coding, students can go beyond developing craft knowledge of programming. Students' games had undergone two rounds of review, and there was a shared understanding that these games were works in progress. Additional analyses are underway to uncover the computational thinking processes students engaged in when coding their games.

Discussion and Future Directions

The study aims to explore relations between knowledge building discourse and computational thinking across the curriculum. More specifically, computational tools serve as objects to think with during Knowledge Building as they can make abstract ideas more concrete, and hands-on creation/manipulation of variables can help students visualize interrelations between core concepts. In Ben's class, working with the Phet simulation enabled grade 6 students to observe how natural selection is the product of the interplay of different variables within an ecosystem. Engaging in discourse around these observations helped students understand how within-species variations can have its evolutionary advantages. In Mike's class, working with the bridge simulations helped grade 3 students visualize how

multiple forces can simultaneously act on different types of structures, which in turn had implications for the material, costs, and shapes students considered when building their own bridges. In Darlene's class, working on creating and improving games on various coding platforms allowed grade 6 students to engage with key mathematical and computational thinking processes across different contexts.

Research suggests that the ability to use computational models to understand concepts, test solutions and critically assess computational models are key computational thinking competencies (Weintrop et al., 2016). Our study adds that collaborative discourse around simulations can trigger opportunities for developing computational thinking competencies. Our future design iterations with teachers aim to advance this work in ways that allow students to take collective responsibility for idea improvement with, around, and beyond the key concepts depicted in computational models. For example, Knowledge Forum scaffolds can be customized to support the dual pedagogical aims of deepening subject-matter understanding and computational thinking competencies. Used in this way, students' knowledge building discourse can be scaffolded to help students make more coherent explanations, predictions, and theories (e.g., "My hypothesis", "I wonder", "What if"), and encourage students to analyze, critique, and extend the design of simulations (e.g., "This model cannot explain..", "What if this model can…", "A better design for this model would be..."). As students progress, they can design their own simulations to test or illustrate their theories using model-building scaffolds such as, "My model", "A better model", "An additional element...", and so on. The expectation is that combining scaffolded discourse in Knowledge Forum with sustained and progressive work with computational models will promote the synergistic advancement of knowledge as well as computational thinking competencies.

Equipping students with computational thinking literacies can empower them to better understand authentic knowledge practices so that they may fully participate in the world in which they live. According to Li et al. (2020), computational thinking is more about the process of thinking than it is about the process of computing. DiSessa (2001, 2018) even goes as far to argue that computation is a new type of literacy in and of itself with long-term implications for how it can transform mathematics education and computation. It is our view that designing models and writing computer programs to construct these models can be considered a form of literacy through which students can negotiate and represent real ideas and problems in a democratic environment where all students are recognized as legitimate participants. In employing the Knowledge Building approach, coding can be seen as an emergent dialogue that develops as learners are engaged in knowledge production in an expansive social system (Dickes & Farris, 2019).

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Teachers Knowledge Building Metaspace to Support Asynchronous Cross-Community Collaboration

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Abstract: This paper proposes a conceptual design of Knowledge Building (KB) Metaspace within the existing Knowledge Forum that connects teachers across communities in an asynchronous collaborative design effort. The KB Community described in this paper has successfully scaled practices by connecting teachers within and across communities. They were even more consistent in sustaining their pedagogical inquiries during the lock-down. The Knowledge building stories and reflection notes of teachers in this community served as boundary objects to connect teachers across schools which became the basis of the concept of the Metaspace design described in this paper. The Metaspace has three major design components: (a) Analytics view, (b) Collective space for reflections, (c) Connecting communities using KB stories as boundary objects. We aim to advance the Metaspace work with a broader community of KB teachers. The pilot study shows promising results to connect researchers, practitioners and other stakeholders via Metaspace. (148 words)

Keywords: Metaspace, knowledge building communities, teachers' dashboard, professional development, infrastructure

Introduction

Research on Computer-Supported Collaborative Learning (CSCL) has made profound progress alongside rapid development in educational technologies and learning analytics (Roschelle, 2020; Leeuwem, 2015; Chen, 2015; Stahl, 2015). Such development has propelled the uptake of innovative pedagogies, such as knowledge building pedagogy, which aims to cultivate students' capacity to sustain inquiries in a collaborative learning environment (Scardamalia, 2006). An essence of knowledge building pedagogy is the sustenance of classroom discourse that involves creating ongoing inquiry questions, theorizing, explaining, and reflecting on the learning progress and subjects (van Aalst, 2009, Yuan & Zhang, 2019). To facilitate such discourse, teachers need to transform their role from knowledge provider to knowledge co-learner, giving students the agency to map and monitor their knowledge goals (Park & Zhang, 2019). This facilitation is complex as students could generate multiple research areas and ideas. New technological and analytical design can be utilized to support teachers in the facilitation. Specifically, data-supported visualizations have been reported to help teachers in the following ways: (i) to help teachers monitor and understand students' learning progress through (Greller, Ebner & Schön, 2014); (i) to support teachers in reflecting their ongoing lesson and in make decisions; and (iii) to support teacher in regulation (Leeuween, 2015); and (iv) to share and plan with other teachers in a community. Some technological designs, concepts, and tools have paved the way for expanding teachers' Knowledge Building communities (Zhang & Chen, 2019) to connect at larger social scales (Stahl, 2013). However, limited studies have been conducted from the teachers' perspectives and needs in knowledge building communities (e.g., Chai & Tan, 2009) and the design of the technological environment to support such communities. This paper proposes a conceptual design of the new Teachers' Knowledge Building Metaspace to provide teachers with continual professional development on KB practices based on what and how teachers share and connect in a physical community.

Background

The purpose of community knowledge building experience is for the teachers to generate ideas and gain experiences in constructing new knowledge of pedagogy through active participation in a creative process. This collaborative design process is complex and challenging. Teachers usually start by learning the theories about these pedagogies, getting examples of how they work, testing lesson ideas, and reflecting on their effectiveness. While they are trying to work on things that were not tried before, they are often anxious about offering their ideas and expressing incomplete understanding. It takes time to build trust and openness and is considered necessary for community growth (Howe & Stubbs, 1997).

Professional development for Knowledge Building practice revolves primarily around collaborative design. Everyone is involved in shaping the lesson ideas andcreating the knowledge of the practice. The goal of this collaborative design is not about getting the most creative or most perfect lesson idea, but it is about figuring out how to respect students' voices and make their questions and ideas count. In such a scenario, every lesson will be uniquely designed and implemented and gives more impetus for teachers to understand the moves and decisions made by another KB teacher. The common space that connects the teachers lies less in the "what to do", but rather more in the "why did she do it this way".

The pilot design of meta-space discussed in this paper is based on the ongoing fruitful knowledge building teacher professional work in Singapore over the past five years. We first provided some background and traced the collaborative design effort, and underwent the following activities as part of their professional development journeys in KB.

(a) Teachers meet weekly to share their Knowledge Building experiences and the related principles. A big part of these meetings is devoted to sharing their own KB stories that comprise analysis of students' artefacts (e.g. drawing), ideas, and questions. Teachers helped each other figure out the next pedagogical move (Figure 1)

Figure 1. Teachers KBC in the weekly discussion, sharing KB stories

(b) Knowledge Forum discussions capture teachers' KB stories. Teachers post weekly updates about their lessons on KF (Figure 2) with specific scaffolding questions (italicized in the quote below) to help them practice principle-based design. E.g. of a teacher's note, "*Did the lesson use ideas that are real and authentic to the students?* - The children shared their experiences based on the experiment conducted. *Were there many different ideas shared?* - children were given the freedom to talk about any of the

following areas: 1. What I liked; 2. What I disliked; 3. What could be done better; 4. What was interesting" - Lesson 8 KB Talk by Teacher Vicky

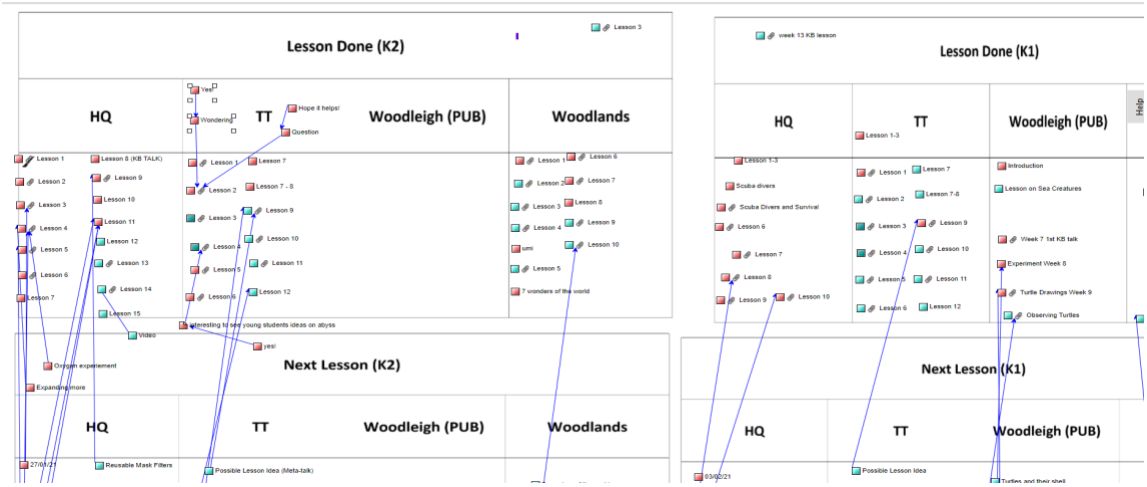

Figure 2. KB stories were captured in the form of lesson updates on a view on the Knowledge Forum view.

(c) Generating reflections. Apart from teachers' weekly updates, teachers also regularly post reflections notes on the view of the reflections. These notes were explicitly designed with distinct scaffold support and questions to get teachers thinking about why and how they designed lessons. The following is an example of a reflection note: "How have I created opportunities for children to share their knowledge and ideas during this time of social distancing? One successful attempt would be the creation of a mind map… and other methods would be the use of google docs where children and their parents had taken time to upload their project. What else can I do to facilitate sharing? I believe I can try the KB circle. The role that I would take would be an observer where I throw questions and sit back and watch the children engage in conversations."

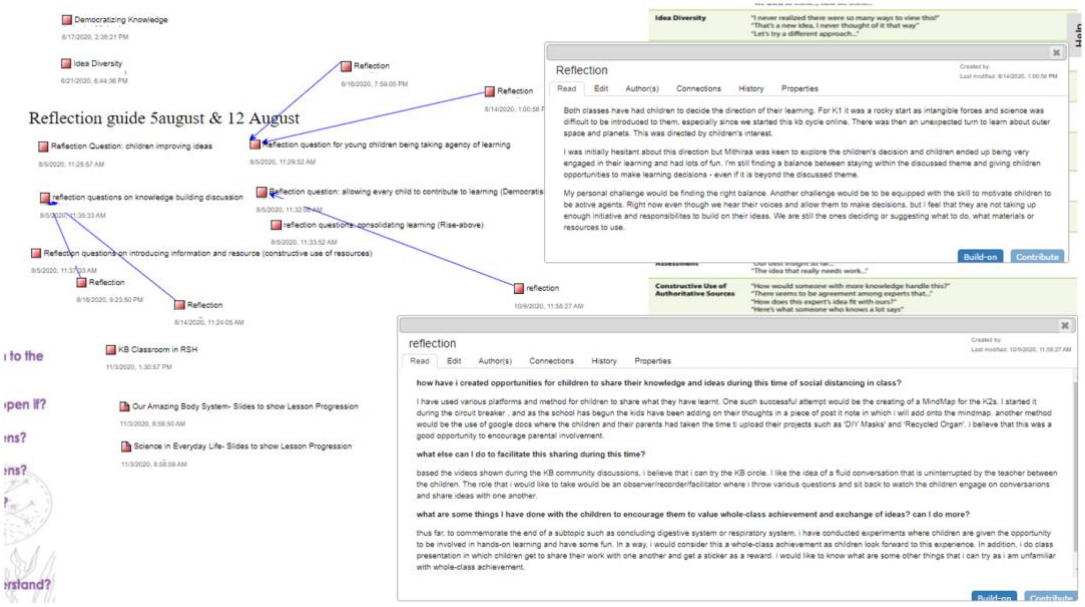

Figure 3. Teachers' reflection view on KF

(d) Cross-school connection. Teachers from different KB schools gathered in KB Community Network Learning Session to present KB stories and share advancement and challenges in their classrooms. These cross-school sessions happen every 3 months.

As collaborative design has shown to reap positive results on teachers' practice and belief (Chai & Tan, 2009), the challenge now is to create a virtual space that connects beyond the teachers' community so that the collaborative design effort is always inclusive of design ideas and perspectives from a wider community and the knowledge created benefits everyone. More importantly, this technology can be used to scale up the collaborative design. On the strong basis of this ongoing current teacher PD work in Singapore (Teo, et al., 2021), we extended to cross-community interaction with teachers from other sites joining the meta-space to advance knowledge building practice.

Conceptual Framework

The Metaspace can be philosophically considered to be a space that transcends the sharing of ideas within a physical or virtual space, one that encompasses meta-objects for Metadiscourse. The Metadiscourse is metacognitive conversations that review the progress of understanding and formulate deeper community inquiry goals (Zhang et al., 2012). It is further noted to be an important discourse move in productive knowledge building (Bereiter & Scardamalia, 2016). Within individual knowledge building communities, this Metaspace may exist as a space that readily provides accessible information and allows singular and bilateral interactions between knowledge builders in the community. A Metaspace allows the participants in the various communities to rethink theory, pedagogies, practices, and big ideas that encompass the communities' roles in the larger society. In short, the Metaspace is an experimental design that applies insights derived through the use of emerging technologies and the study of teaching practices (E.g. knowledge building stories and teachers' reflection notes) to produce knowledge infrastructure that engages communities of knowledge builders (see Figure 4 below).

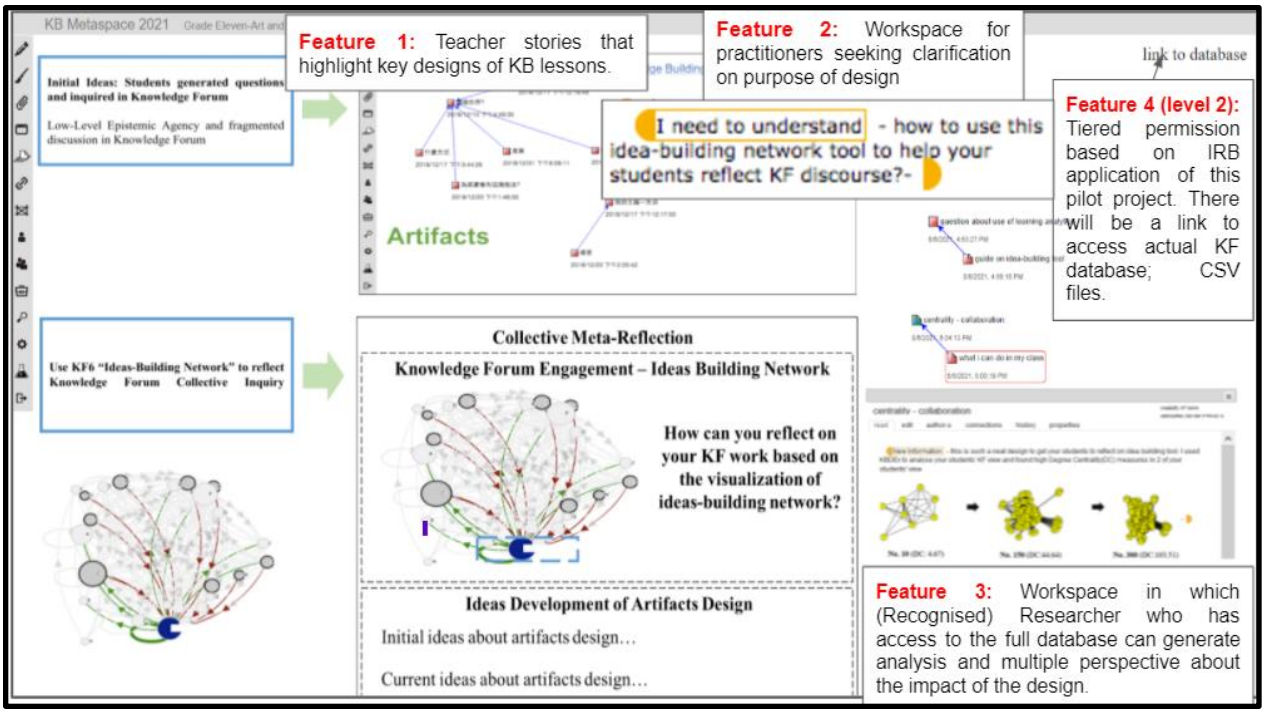

Figure 4**.** A protocol of KB Metaspace: Teachers will access this Metaspace and update their KB lessons (Feature 1) and interact with other teachers (Feature 2). Teachers will also get data-supported analytical visualizations based on their bi-weekly teachers' reflection notes to monitor the classroom's idea progress (Feature 3). All the data will be stored in the KF database (Feature 4).

Following are three proposed design features of the KB Metaspace:

(a) Analytics to provide meta-view of KB lessons

Learning Analytics is applied and understood differently in various educational sectors, with collected and analyzed data is understood differently in various contexts. Especially in recent years, the relationship between learning theories and learning analytics practices has become a hot topic (Chen, 2015, Leeuwen, 2015). However, the possession of data is not sufficient to advance learning and make significant changes since the pedagogical approach must be considered in a holistic view. One of the values of analytical feedback for teacher practices is the timeliness of the feedback that helps teachers manage overwhelming classroom learning information and design intervention early (Greller, Ebner & Schön, 2014). The data-supported analysis largely reduces teachers' cognitive load and increases their confidence in decision-making (Leeuween, 2015). The analytical tools and designs in the Metaspace are more than just data, but the visualization of the data in a more readable and understandable format like graphs and charts. These will drive teachers' KB lesson plan for informed decision-making. The visualization of the feedback is an incentive to take new actions. It provides potential insights or patterns from the massive data pool, for instance, having better eating habits (Duval, 2011), writing higher quality notes (Zhang, Yuan, & Bogouslavsky. 2020), or making suitable policies (Pechmann, 2019).

Moreover, students' emerging KB inquiry interests bring new challenges for teachers to monitor each student and the whole classroom's learning progress among the complex social interactions. Thus, the Metaspace will provide state-of-the-art of classroom's progress, which drives teaching plan decision-making, and supports the continuous improvement of the KB lesson quality over time. In the Metaspace,

the workspace in which a researcher who has access to the entire database can generate analysis and multiple perspectives about the impact of the design. Teachers will use the analysis based on their KB stories and teacher reflection notes to identify the key ideas, connections, dynamics of idea progress (Figure 5). The cross-community interactions will use reflection notes and visualization to increase information exchange and deepen collaboration.

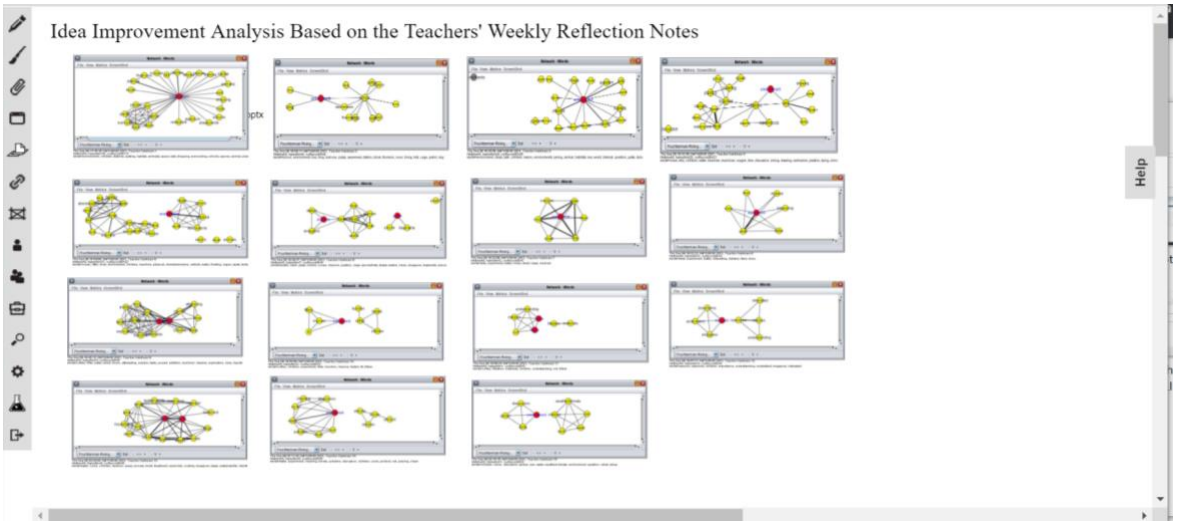

Figure 5. A protocol design of Feature 3 that provides analysis results based on teachers' reflection notes from a typical learning cycle (15 weeks). Each circle represents a keyword. Based on the keywords and connections, this view aims to facilitate the teacher's interpretation of how ideas progressed over time.

(b) Collective space for reflections

Reflective assessments have been perceived as part of self-assessment and reflective dialogue. Reflection has often been described as a deep and interpretive process that contains careful judgment, active, persistent, and one's belief of the supposed form of knowledge (Slade, Burnham, Catalana, & Waters, 2019, Dewey 1901, Zeichner & Liston, 1996). Reflection also takes three forms: before, during, and after action. Reflection takes before and after the action are reflection-on-action, while reflection during the practice is called reflection-in-action (Schön, 1983). Moreover, teachers' reflections have various formats, including reflection notes, surveys, and dialogue, or considering reflection as a multi-dimensional construct (Moore-Russo & Wilsey, 2014). In this Metaspace, reflection takes two formats: KB story and Teachers' reflection notes. The KB story summarises the whole learning cycle (Reflection-on-action), and the Teachers' bi-weekly reflection notes reflect their teaching activities and their teaching plans for the next few weeks (Reflection-in-action).

In traditional teachers' reflection research, participants reflect on their own teaching strategies or noticing and seek improvement based on their judgments (Barnhart & van Es, 2015). The teachers rarely reflect on their teaching practices to advance collective pedagogies on a larger social scale over a more extended time. This paper attempts to address this gap by proposing a collective reflection space where teachers' reflections can be continuously shared, build-on, and revised in a community (Slotta et al., 2014).

(c) Connecting teachers' KB stories across communities using boundary objects

Research has made significant progress in increasing collaborative virtual learning environments (Scardamalia & Bereiter, 2006, Zhang & Chen, 2019). Since the last decade, new designs have emerged to extend collaborative interaction at higher social levels and scales (Stahl, 2006). These new designs encourage participants to extend their conversation and sustain their inquiries across years for sustained knowledge building inquiries. Participants in different communities can join a new workspace to work on a new task or solve the problem at a higher level via information exchange with cross-boundary collaboration. Although considerable research are devoted to the cross-boundary interactions with young students and single-layer interaction (Laferriere, Law, & Montané, 2012), less attention is given to teachers' cross-boundary interactions. One of the biggest challenges for cross-boundary collaboration is information exchange. To tackle this challenge on information exchange, we embed boundary objects to mediate the cross-community workspace. These boundary objects are artefacts that bridge the information gaps between various communities (Star & Grisemer, 1989). The boundary object has a unified structure for efficient communication as it is earlier for recognition across different social contexts (Star & Gristmer, 1989). The boundary object with its feature of "flexible interpretation" as a means of translation allows multiple community members to use it differently to fit the local needs. This paper proposes the usage of *teachers' reflection notes, KB story, student and teachers' analytics work* as their boundary objects for teachers' cross-community collaboration (Figure 2 & 3). Through interacting with shared boundary objects, participants from multiple communities can raise questions, ask for more information, seek collaborations, add on new insights, and reflect on their teaching practices, which could deepen their understanding (Akkerman & Bakker, 2011).

Pilot Study, Initial Findings, and Discussion

This paper conducted a pilot study with a prototype design space that produced a meta-view of knowledge building design work across teacher communities in Singapore, Hong Kong, and Shenzhen, China. The Metaspace ensures advances in research, design, and practice. Specifically, the underlying rationale for designing this Metaspace stems from the need to continuously support teachers' professional development and cross-community interactions for knowledge building. The design uses teacher stories and teachers' weekly reflection notes alongside classroom artefacts and analytic tools to highlight teacher inquiries and knowledge building practices (Figure 5). Researchers' analytical work supporting teacher designs and collective progress within and across communities are also prominently brought to the fore, featuring enactment and interactive designs in cross-community teacher meetings.

Conclusion

In summary, community-based learning for teachers has long been constituted as a cornerstone of professional development and deep learning respectively. The related concept of knowledge building practice and technology has made significant progress over the past decades to support such learning. However, as the education fraternity lived through the impact of the various lock-down and social distancing measures, the notion of collaborative design and community-based work suddenly came to a standstill. We need to look beyond synchronous and asynchronous platforms to level up the quality interactions of minds and ideas that they were more accustomed to in class. Here we discuss a conceptual Metaspace that attempts to bring different communities into a metadiscourse in the existing and emerging teaching and learning context. This Metaspace prototype will continue to be tested and we will measure the impact of this Metaspace of teachers' professional development on KB practice.

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Knowledge Building: Facilitating Metalinguistic Awareness and Scientific Understanding in Parallel

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Abstract: This pilot study explored possibilities of advancing English language and science understanding in parallel through pedagogical supports to enhance linguistic awareness in written discourse on Knowledge Forum for low-proficiency English language learners. Two Japanese students and their parent/teacher participated in the 4-week study. Multiple data sources were qualitatively analyzed to identify issues students experienced with translation and dictionary enhancements to Knowledge Forum. Results showed that both students advanced their understanding of English language as well as their topic of inquiry—Human Exploration of The Moon and Mars. The translation provided external representation of Japanese and English versions of their ideas. Both students used the translation enhancement as a "theory-testing tool," treating the translations of their text as manipulatable, revisable objects. The translated text seemingly reduced cognitive demands associated with production and evaluation, allowing them to attend to issues that would have required mental translation otherwise. Student use of the translator and dictionary informed next-generation designs to allow students with limited language knowledge and/or L2 capacity to experiment with lexical and syntactic differences in their native and L2 language inputs and outputs.

Introduction

A number of studies suggest parallel literacy and subject-matter development in L1/native language (Chuy et al., 2011; Resendes et al., 2015; Khanlari et al., 2019) and L2/second language knowledge building classes (Manegre & Gutiérrez-Colón, 2019, 2020; Zhao & Chan, 2014). However, novice writers might be less aware of problems in their writing than more intentional "expert learners," and fail to address problems, leading to increased knowledge gaps over time (Tsuji & Scardamalia, 2020).

Past intentional learning literature suggests an early knowledge/achievement gap between novice and expert students may expand over years (Bereiter & Scardamalia, 1987). They argued that novice learners engage in "Knowledge-Telling" relying on content retrieval from long-term memory while expert writers engage in "progressive problem solving" (Scardamalia & Bereiter, 2010) or "Knowledge-Transformation," characterized by repeated cycles of entering content into discursive space with attention to both content and rhetorical features of their texts, enabling them to address ill-defined, complex goals. Novice writers, in contrast, may fail to evaluate content, linguistic, and rhetorical features of their texts, focusing on knowledge production due to high cognitive load; thus, the feedback loop bridging the content and discursive space is not available for novice learners (Scardamalia & Bereiter, 1987).

Although not directly discussed in the literature, L2 learners likely engage in knowledge-telling, as it demands less cognitive resources (Coughlin & Tremblay 2013; Van den Noort et al. 2006). Fukuta and Kusanagi (2015) reported that advanced Japanese English Language Learners (ELLs) produced syntactically and lexically complex texts even when handling tasks that required greater cognitive effort.

Literature suggests the importance of systematic awareness of language, or metalinguistic awareness, for second or multiple language learning (e.g., Bouffard & Sarkar, 2008; Nagy & Anderson, 1995; Thomas, 1988). Metalinguistic awareness includes "activities of reflection on language and its use" and the "subject's ability intentionally to monitor and plan their own methods of linguistic processing (in both comprehension and production)" from phonological, syntactic, semantic, and pragmatic aspects (Gombert, 1992, p.13). Schmidt (1990) argued that conscious noticing/awareness of a gap is required for knowledge internalization. Comprehensive output hypothesis (Swain & Lapkin, 1995) also emphasized the role of awareness/close examination of outputs for attending to structures of language and internalization of knowledge.

With expectations to conduct further testing of pedagogical supports in local and global contexts, we conducted a pilot design study with low-proficiency ELLs to address the following research questions: 1) Is it possible to design learning analytic tools to enhance both metalinguistic awareness and science understanding through feedback to oral and written discourse for ELLs with low English language proficiency?; and 2) What

design issues arise in implementing pedagogical supports and learning analytic tools to advance language and content understanding?

Methods

Two Japanese children, Takuma and Riko (pseudonyms) and their father as the teacher, participated in this pilot study. Takuma and Riko were in the fourth (11 years old) and seventh (13 years old) grades, respectively, receiving traditional teaching at the time of study. Both students were ELLs with low to lower-mid English language proficiency according to their previous test scores and CEFRL (the Common European Framework of Reference for Languages). The teacher had over 17 years of teaching experience with no prior experience with Knowledge Building or any other student-centered approach. Prior to the study, he studied Knowledge Building and Knowledge Forum designed to support the pedagogy, co-designing his teaching plan with the first author.

Research Context

Students voluntarily participated in this 4-week study to advance language knowledge through Knowledge Building on the scientific topic, "Human Exploration of The Moon and Mars." They engaged in this at home as extra work. During the same time period, they attended regular English education classes at their school. They first completed a pre-test—a short essay written on Knowledge Forum on what they knew about the Moon and Mars—without any supports. They then attended their first weekly online Zoom session (45 minutes). Subsequently, students engaged in oral (Japanese) and written (English) knowledge work for 30 to 40 minutes per day, 2-3 days a week. In completion of the final session, students wrote a post-test under the same condition as the pre-test writing. For reading and writing on Knowledge Forum, students used online translators including DeepL (https://www.deepl.com/translator) and Google Translate (https://translate.google.com/). Students were instructed to *approve* texts as 'their own' by fully understanding translated texts at syntactic and semantic levels and/or revising translated texts. The first author tested a framework for language-concept idea improvement on Knowledge Forum (Figure 1), to facilitate science and English language improvement through switching between content and rhetorical spaces without interrupting the flow of ideas.

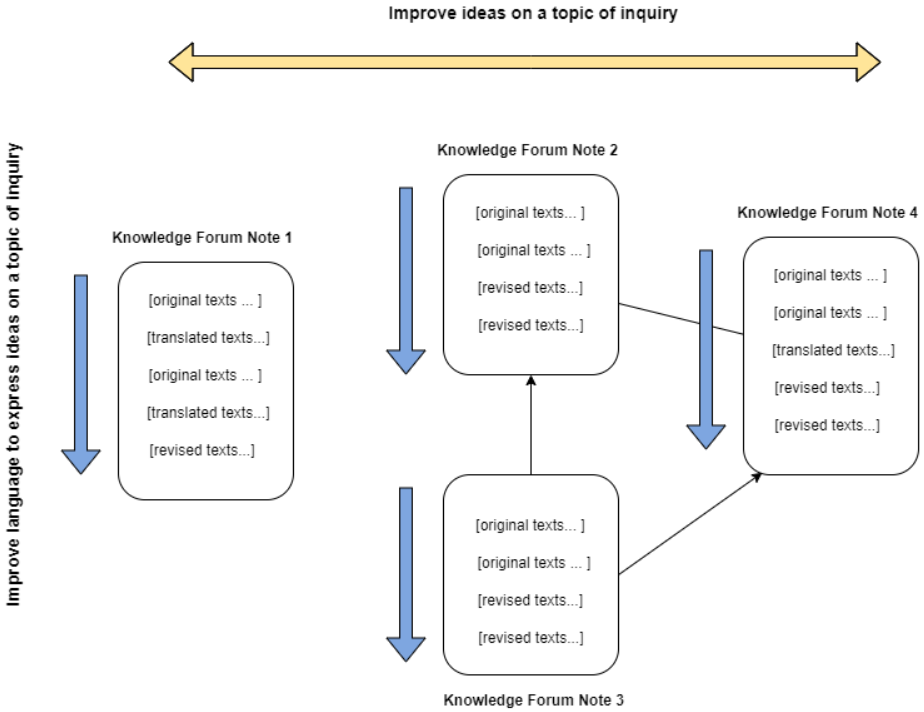

Figure 1. Framework for Language-Concept Idea Improvement on Knowledge Forum.

Students created new notes for content (i.e., idea improvement *across* notes); at the same time, they included original, translated, and revised texts *within* one note. As a means to monitor vocabulary growth and enhance

awareness to their lexical knowledge, we introduced an initial prototype of the Dictionary (see Figure 1 for its interface). Students had access to words they had used on Knowledge Forum with sentences and misspelled words. Results could be further filtered (Figure 2) based on type of words (all/science), user, word levels (e.g., 1st 1,000/2nd 1,000/3rd 1,000...), and stop words (e.g., articles, pronouns).

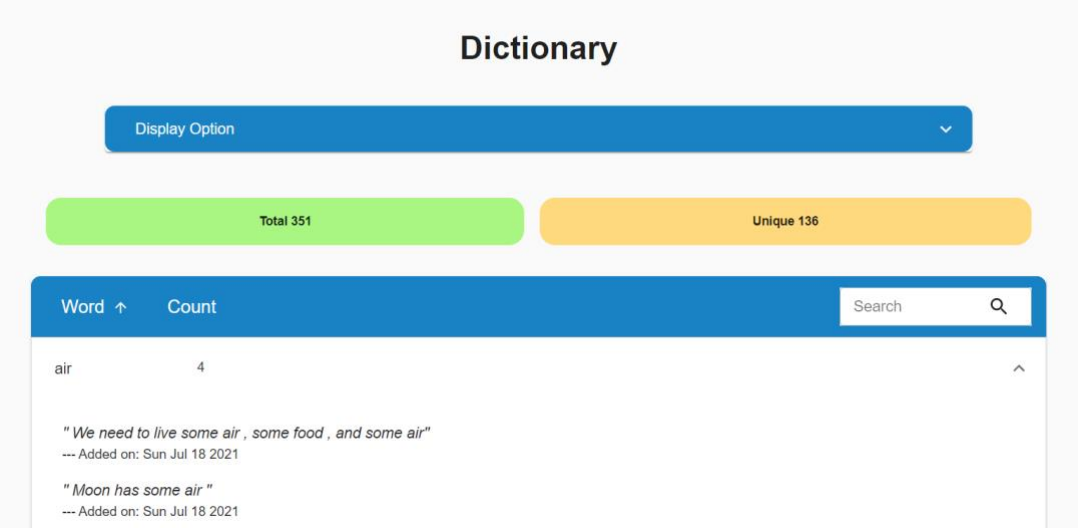

Figure 2. The Dictionary Interface Design.

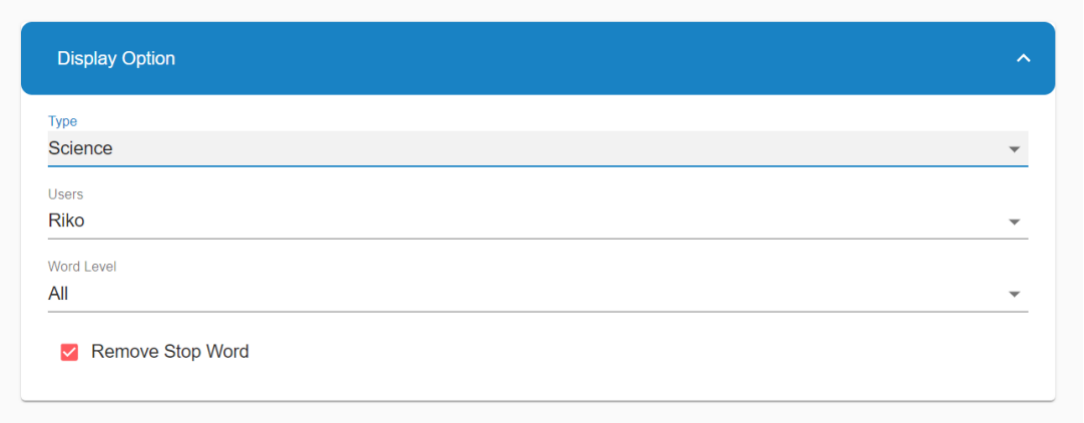

Figure 3. Display Options of the Dictionary.

In an informal family session, the two students and teacher decided to switch between two modes—informal "family sessions" to discuss shared and 'individual' reading and writing on Knowledge Forum and more formal reading aloud of texts they were entering—in a shared temporal and physical space at home. Interestingly, this individual reading and writing involved a collaborative aspect: one student's unconscious slips of verbalized thoughts and findings during the process of reading and writing influenced ideas and interests of the other. As noted in the teacher's notes, this practice had been observed frequently during the study and effective for identifying issues and plans for further inquiry.

As the Mars view in Figure 4 shows, there were not many interactions on Knowledge Forum. Students tended to build on their own notes; for example, Riko (u17567w) built on his notes twice to respond to his question. They mainly used the platform to anchor ideas that emerged during oral discussion and individual inquiry instead of expanding ideas on the Forum.

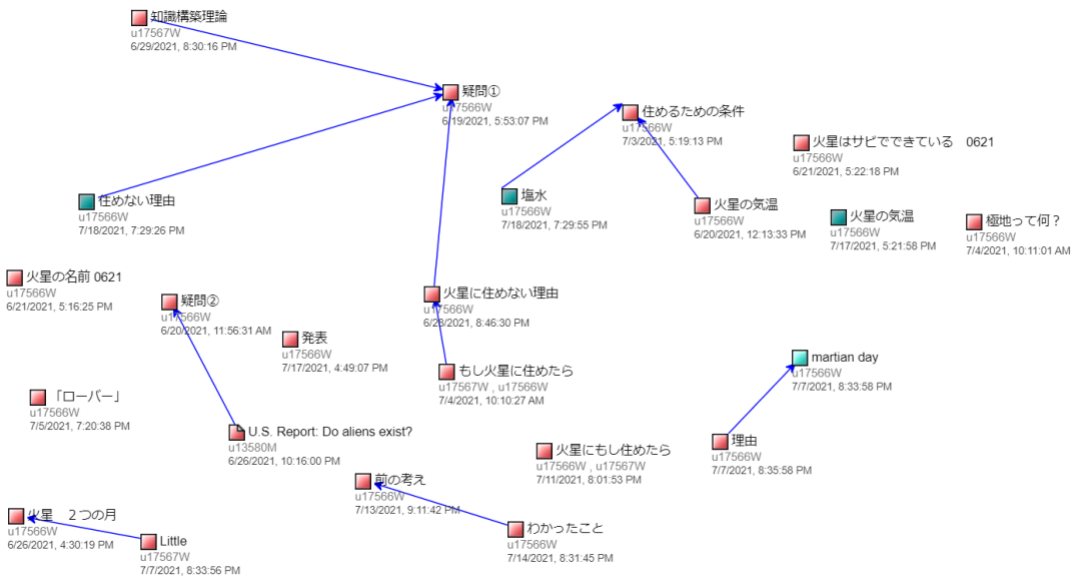

Figure 3. Knowledge Forum Notes in the "Mars" View.

Data Sources and Analysis

Data sources included: videos of weekly Zoom online sessions, Knowledge Forum discourse data and meta-data, analytics tool outputs, reflection journals submitted by the teacher, written dialogues of informal student-teacher interactions at home, pre- and post-writings, and the researcher's field notes. The first author open coded the data with NVivo and then identified relevant information to address research questions.

Results

Is it possible to design learning analytic tools to enhance both metalinguistic awareness and science understanding?

Use of Translators as a "Theory-Testing Tool"

Unexpectedly, translators became powerful tools to facilitate reading and writing. Without a teacher's intervention, students developed their own strategic use of translators as shown in the following writing and reading procedures:

1. Write down content they wanted to express in Japanese on DeepL
2. Translate the Japanese texts into English and examine two versions to compare
3. Use the read aloud function of translators to check pronunciation
4. Type the translated texts on Knowledge Forum with or without original Japanese texts

To use translated texts with or without modifications, they closely examined the two versions. In this process, they entered slightly different Japanese texts to examine variations in input-output combinations, treating DeepL as a device to experiment with. For example, Takuma simplified Japanese texts he entered on DeepL and examined gaps between the initial and new translated results.

When reading English texts, they used a similar approach. For example, Riko used the following strategy to read and use English texts in her notes:

1. Enter English texts they want to read into DeepL
2. Simplify or summarize the translated Japanese texts
3. Enter the simplified Japanese texts into DeepL
4. Read the generated English texts and manually entered them once she intuitively judged that she understood them all

In addition to these, Takuma broke down long sentences into smaller portions and then translated each, followed by suggestions from the teacher and Riko, to ease difficulty of understanding complex texts. Through these processes above, students likely tested three types of theories about English language: 1) meanings of words students had no or limited knowledge of when reading; 2) appropriate forms of words when writing; and 3) appropriate word orders to express their ideas in intended ways.

Social interactions during reading and writing using translators were critical for facilitating comprehension and production of text. As students engaged in "think aloud", or verbalization of immediate thoughts and reflection (Bereiter & Scardamalia, 1987), they corrected their immature understanding of English language. Riko occasionally corrected Takuma when he read his words or sentences aloud, which he frequently engaged in throughout the entire study without being encouraged or instructed:

> Takuma: [reading aloud texts as he is entering them on Knowledge Forum] *Can you live* [pronounced as "raibu"] *on Mars* [pronounced as "mass"]?[1]
> Riko: Isn't it "*live*"?
> Takuma: Oh, "*live*"? Not "raibu" [entering the sentence on Google Translate]? (In Japanese we pronounce the word spelled "*live*" as "raibu")
> Riko: Was it correct? Could you do it? [looking over the screen of his PC]
> Takuma: [After hearing Google Translate pronouncing the sentence in a correct way] *Live*.

Similar interactions were observed in Week 3:

> Teacher: What is written in this sentence?
> Takuma: Um, I am guessing it's evidence, or a reason? And, umm, *liquid* [pronounced as "rikuido"]?
> Riko: *Liquid*?
> Takuma: *Liquid* is, *sal*, *salty*. It means little.
> Riko: Salt.
> Takuma: Salt?
> Riko: It means salty water, right? *Salty Water.*
> Takuma: Then, that means there is [water on Mars].
> Riko: It means there is [water] in the ground.
> Takuma: There is salty water in the ground. So, that means there is water [on Mars]. [Writing the new finding on Knowledge Forum] Um, *new information*? And then…well, *Mars*, *Mars*… Oh [noticing something], *Mars, Mars on ground.*
> Riko: *In the ground*.
> Takuma: *Mar*… What? *Salty water*. Is this right?

Conceptual Advance

In early weeks, students had only vague ideas about the Moon and Mars as indicated in their responses to a question whether they had seen Mars: "something round", "something red", and "something that looks hot." They seemed lost in what to answer when being asked whether humans could live on other planets. Perhaps for this reason, their early Knowledge Forum notes mostly contained unelaborated questions and information they gathered during reading resources.

- *[I need to understand] 火星には住めるのか can you live on mars?*
- *[I need to understand] how the moon is made*
- *[New Information] 火星の気温は低い方だった The temperature on Mars was lower*
- *[My theory] 火星は、サビでできている mars is made of rust*

In Week 2, students gradually expressed their ideas regarding the possibility of living on the two planets, including the discussion of benefits to live there and potential solutions for issues preventing human settlement:

- *[My theory] i can't live mars. i don't think mars is habile because its gravity is sifferent from earth's*

[1] All inserted student-teacher dialogues were English translations. For English words/sentences students said in the dialogues were italicized to make distinctions.

- *[My theory] Some day we can live on the Mars. Because I think l'd develop clothesline and features that could regulate temperature and gravity. Because I think when it's more developed, we can adjust it better. The place will be more spacious. for example nuciear power would pollute the environment but if we could do it on mars we could generate power there.*

During the final session, they first presented findings and their thoughts for the overarching theme, "Can humans live on the Moon and Mars?" To our surprise, Riko expressed her intention to present it in English and confidently did so, using a script she had prepared before the session.

> *I think we can live on the Moon after 50 years.*
> *We need to live some air, some food, and some air.*
> *Moon has some air.*
> *But moon doesn't have sunlight.*
> *Then we couldn't charge sun energy.*
> *So we couldn't use fire and light.*
> *Also Moon doesn't have some food.*
> *Then we couldn't save energy to live.*
> *But now world technology is growing.*
> *So after 50 years ago will develop solve these problems.*
> *Because I think we can live on the Moon after 50 years ago.*

Takuma prepared and presented his script in Japanese:

> I thought I could not live on Mars now. Because temperature on Mars is different from Earth's by 120 degrees and gravity is also different. It is also because there is nothing like clothes to adjust the temperature on Earth right now.

After each presentation, we had a brief Q&A session, followed by further discussion of raised issues preventing them from living on the Moon and Mars. They asked questions to each other, elaborated on findings they had presented, and continued theorizing from the "Moon" and "Mars" expert perspectives.

> Riko: What do we need to live on Mars?
> Takuma: To live on Mars, I studied that (Mars should) have temperature and gravity like Earth, if there is water, and if we could build buildings.
> Teacher: Was there anything we already satisfied of the conditions?
> Takuma: Water. I mean, there was salty water.
> Teacher: So, the water problem is cleared?
> Takuma: And we could build buildings.
> Riko: So, are there buildings already?
> Takuma: We could send in rovers so that means we could build them.
> Teacher: There could be machines, so that means we make them bigger as buildings and people can live there, is that right? Did you study in what condition water exists?
> Takuma: For water, Mars is made of rust, and in and under the rust salty water is stored.
> Teacher: *Salty water.*
> Takuma: *Salty water.*
> Researcher (first author): How much salty water is there?
> Takuma: There is a little on the surface of and in Mars, so that means there is only about a year-supply because the size of Mars is about half of the Earth.

Although their conceptual understanding was still limited, they quickly responded to questions, providing their opinions based on their knowledge and citing evidence from authentic resources. They sometimes opened and quickly read some of their past Knowledge Forum notes; however, its purpose was not to recall information but rather to ensure accuracy of the information they gave to others.

According to a formal assessment conducted by the teacher after the completion of the study, students had successfully met his curriculum expectations despite a slow start in early weeks.

Language Advance

Several sources of data in this study indicated lexical and syntactic knowledge advance even without direct language instruction. Most evident was changes in pre- and post-test writings (see Table 1). In his pre-essay, Takuma initially wrote:

moonbig
sarkur

It contained only three words, one of which was illegible, to express two of his initial ideas about the Moon. He had one spacing error (*moonbig*). Riko wrote:

Moon is diffirennt form each day.
Monn is shining by sun.
Moon is very far from the earth.

Her pre-essay contained three complete sentences, 13 unique words, and 18 words in total. Although she had no spacing errors, her writing contained three spelling errors (*diffirennt, form, Monn*). Domain-specific words were limited to basic ones (*moon, sun, earth*).

After the 4-week period, both quantity and quality of their writings have significantly improved. Takuma wrote:

mars is cold.
mars on guround solty water.
I cant live on mars.
mars day 24.6 mirions.
mars erars 635 day.
mars skerl a harf Earth.
mars on no ear.

His post-writing contained 19 unique and 28 total words in seven sentences. Some sentences were lacking verbs and contained spelling errors (*ground, solty, mirions, erars, skirl, harf, ear*); however, it clearly demonstrated his improved fluency as well as lexical and syntactic knowledge.

In her post-writing, Riko used 60 unique and 124 total words in 14 complete sentences. Compared to her initial writing, she had used various domain-specific words (e.g., *ground, salty, ice, water, temperature, space*), using greater grammatical variations.

moon has some water in the ground.
these water condition is ice and water.
but these under the ground so these ice is don't melt.
moon tempreture is very different is Japan.
noon is more than 120℃ but night is -80℃.
moon is birth by jiant impact.
moon has not only water but also air
I don't know moon and mars before.
then I can start this program I can learn more imformation of moon and mars.
And I can learn important of talking my theory.
moon and earth different thing is what have is the space.
earth is enough thing to live.
but moon has not have air and water.
so this thing is most of different thing earth and moon.

Table 1: Changes in Pre- and Post-Test Writings.

	Pre-Test					Post-Test				
	Total	Unique	General	Domain	Misspelling	Total	Unique	General	Domain	Misspelling
Takuma	3	3	1	1	1	28	19	13	6	7
Riko	18	13	10	3	3	124	60	48	12	3

Note. One of the three words Takuma used in his pre-test writing was illegible and thus was not included in general and domain counts.

During a follow-up interview students reported that they were aware of receptive and productive vocabulary increasing during the study. Takuma mentioned that he could immediately recognize Mars-related words because he frequently used them and wrote in 'right' orders. This indicates that some levels of lexical and syntactic awareness existed in the process of producing sentences using DeepL Riko reported greater fluency when writing, saying, "I could write more smoothly when I directly wrote in English." According to the teacher's report submitted in Week 3, she also said, "English phrases are coming out easily" as she was reading English texts.

In addition to lexical and syntactic knowledge advances, students rapidly increased intention to write 'original' English texts. Although students had not attempted making modifications to the translated texts in early weeks of the study; they gradually showed a greater intention to use "original texts" scaffold without using translators. During the Week 3 online session when Takuma was asked his plans for the coming week, he explicitly said that he would like to write original texts more. Figures 4 and 5 show examples of notes containing the three scaffolds.

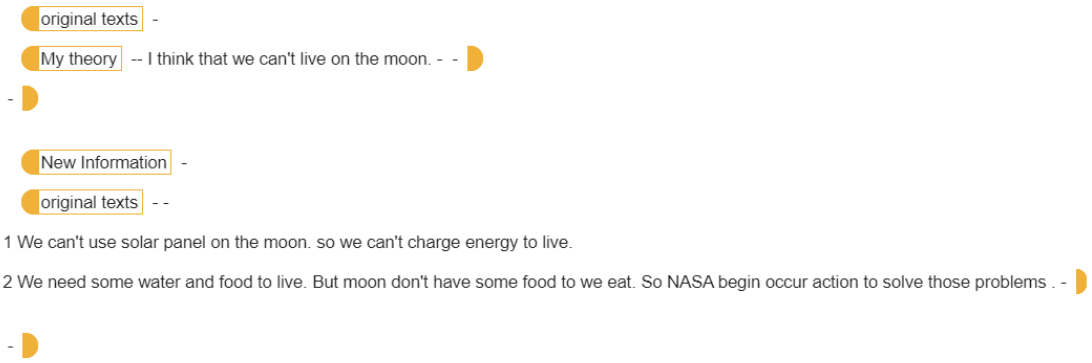

Figure 4. Riko's Notes Using her 'Original' Texts.

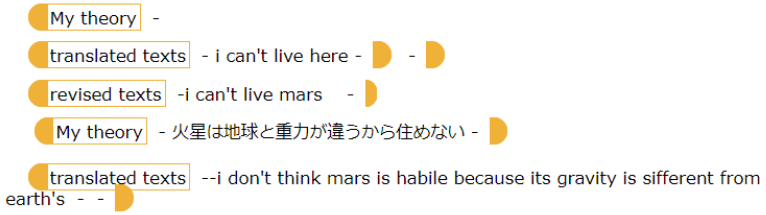

Figure 5. Takuma's Notes with Translated and Revised Texts.

Both students stated that the reason for a greater intention to write original texts was that at some point they realized and believed that translated texts did not belong to them and confused them when they reread the texts later. In addition to this, Riko also mentioned a growing interest in challenging herself with composing original English texts using her knowledge. The teacher later noted that this change was perhaps due to the increased vocabulary. He also noticed that students were less resistant to reading and writing in English with increased confidence in expressing their thoughts with knowledge acquired through the process of reading and writing using translators.

What design issues arise in implementing pedagogical supports and learning analytic tools to advance language and content understanding?

Students made limited use of the Dictionary and Knowledge Forum analytics. The teacher and first author agreed that this was not necessarily due to lack of interest but lack of time and mental resources for this additional work. The teacher frequently noted great mental effort associated with switching across different platforms to write a few sentences in a single note, which took about 10 to 15 minutes on average. Because students were already dealing with this challenge, he was concerned about further encouraging them to use analytics for assessment.

Although students barely used the Dictionary during the study period, when they had a chance to do so, they noticed problems and corrected errors. After the final Zoom session, the teacher decided to voluntarily invite students to use the Dictionary tool together to discuss words they had used. During the follow-up session, he observed that Riko read through a list of words she had used, mumbled, "Oh, this one is wrong", and then corrected the mistakes in Knowledge Forum notes. For words she could not immediately spot mistakes, she chose to not correct, mentioning that it was difficult to locate mistakes in them. Takuma struggled with identifying correct and incorrect words and paused until the teacher suggested that he examine words with Riko. As she read through a list of his words, suggesting words containing errors, he opened and revised his notes. In their post-writings they submitted after the brief session, words they initially misspelled were correctly spelled, which indicates that students noticed and self-corrected errors in their knowledge through examination of words in the Dictionary.

Discussion

The current study explored cases of low-proficiency ELLs in Japan to identify design issues and inform the development of software and pedagogical supports to enhance metalinguistic awareness within the context of advancing science and language knowledge in parallel. Issues emerged through the process, such as cognitive overload due to the need to switch between different platforms and languages (see Sweller et al., 2011 for split-attention effect). These clearly need to be addressed in future designs to help language/literacy learners, including low-proficiency ELLs and low-performing groups in English as a first language.

One significant insight was the role of translation as a theory-testing tool to help students with limited English language knowledge compose English texts and facilitate knowledge-transformation at the time of composition through experimenting with L1 and L2 output variations. Output evaluation is usually retrospective, with immediate focus on content; that is, students produce ideas in L1 or L2 without reflecting on rhetorical aspect at the time of writing—and may not reflect on them later. This suggests the need for learning analytics to support objective analysis and reflection on writing in real time. In the case of students in this study, they repeatedly explored better ways to express their ideas using DeepL *every time they attempted writing a note*. Nawal (2017) explains that L2 learners do not generally think over their outputs because of mental effort spent for composition itself. However, for these students, content and form of "in-process" text was *visible* and *manipulatable* (see Risko & Gilbert, 2016 for cognitive offloading), providing means of writing and evaluating texts using L1 capabilities while composing. Immediate output testing and experimenting seems a promising strategy to be further explored with different groups of students, including low-performing English as a first language students, low proficiency ELLs, and young children in various contexts.

Finally, results of this study need to be cautiously interpreted. There were only two participants, and their parent, with high motivation toward intellectual challenges, was the teacher. In other contexts or with other students there might be less willingness to contribute ideas, maintain harmony with other students, and work to avoid mistakes. Possibly, the students in our study were less resistant to the challenge of exploring unknowns, beyond finding simple "right or wrong" answers. So, the participants may not represent average Japanese students and the study itself was exploratory, possibly not repeatable.

Conclusion

Findings of this study will inform further research and design in more formal research contexts. Clearly, more intuitive tools are needed to facilitate experimentation with input-output variations and to enable seamless integration of tools to facilitate awareness to language and rhetorical issues during scientific inquiry. With this study as an initial step, we plan to design refined tools and pedagogical practices to help all learners extend subject-matter boundaries and linguistic sophistication across a wide range of contexts.

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SHORT PAPERS

Discussing problems about the implementation of the KB in classroom with teachers: a case analysis of the "Classi in rete" project

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Abstract

Successful knowledge building is characterized by the generation of explanatory problems (Hakkarainen, 2003). These types of problems are, in fact, those on which it is possible to activate a progressive problem solving. During the training phase of the project "Classi in rete", promoted by INDIRE in a network of small schools of Abruzzo (Italy), a community of 22 teachers from primary and lower secondary school participated in an online discussion in KF, focused on identifying problems in implementing the KB model in their classrooms. In this case analysis we addressed the following questions: In which thematic area are the problems identified? What characteristics do these problems have? What is the most elaborate problem? What solutions are proposed to the problem most elaborated? Results show that problems were mainly focused on technology and were of an explanatory nature. The most elaborated problem refers to didactics, it is of an explanatory nature and in particular concerns how to use the KB in the first classes of primary school. The content analysis inspired to the Grounded Theory identifies the "Facilitation of the activity in KF" as the core category of the solutions proposed. Implications for the implementation of KB in classrooms are discussed.

Introduction

The typical school organization dating back to the sixteenth century and definitively established during the nineteenth century (Maulini & Perrenoud, 2005) is still the dominant educational model. The topological *becoming of the school* (Fenwick & Landri, 2015) and the development of a new order of space-time continuity make new organizational forms emerge, developed mainly in rural areas and typical of "small schools" (Mangione, Cannella, Parigi, & Bartolini, 2020). A pedagogical use of ICT has a great potential for small rural schools and requires rethinking educational and organizational models in scenarios of remoteness (Mangione & Cannella, 2020). INDIRE studies aimed at accompanying the integrated use of technology as a part of educational models capable of strengthening teacher competences and enriching the educational practice in rural areas, thus supporting teachers in preparation, recruitment, and "retention" (Mangione & Cannella, 2020).

The cooperation started in 2018 between INDIRE and École éloignée en Réseau (ÉÉR), Quebec, allowed to deepen an educational model capable of improving the management of small and isolated classes, characterized by multigrade classes (Allaire, Laferrière, Gaudreault-Perron & Hamel, 2009). "Classi in rete" is a hybrid model (combining online synchronous, asynchronous and face-to- face activities), based on the idea of working with classrooms as Knowledge Building communities (Scardamalia & Bereiter, 2010; Cacciamani & Messina, 2011). "In "Classi in rete", delocalized classes aim to design a common disciplinary path involving student groups in parallel in the same activities by adapting calendars, spaces, and teacher roles (Mangione & Cannella, 2020) Teachers of delocalized classes share cooperative educational practices such as "pairs aidants", "mentorat" or "delocalized equipe" by using Video conferencing and Knowledge Forum (KF) (Mangione & Pieri, 2019).

The "Classi in rete" model follows three pedagogical principles (Mangione, Pieri, Tancredi & Nadeau-Tremblay, 2021):

- *The classroom as a learning community*. An environment that fosters collaboration and is characterized by a particular class dynamic as it promotes respect, dialogue, and mutual help. The pedagogical intentions, similarly, to the learning intentions of the students, are formulated openly and all, according to their specific aptitudes, contribute to achieving the desired learning goal. Collective investigation activities are encouraged because they help to understand and solve problems that the teacher can relate to the course of study;
- *Teach for problems*. The study of authentic issues is the heart of the pedagogical approach of "Classi in rete". Teaching for problems means involving students on real problems while leaving room for their creativity and allowing them to deepen their individual and collective understanding of the topic;
- *Promote dialogue through technologies*. Involved in the study of a real and authentic problem, students are first invited to ask questions and express ideas about their understanding of the problem and then to improve all together the seemingly most promising ideas to better understand, or even solve the problem. The class dialogue, fueled by written contributions published on the knowledge forum and by verbal exchanges in the classroom or by videoconference, progresses as students analyze the various aspects of an issue, the results of a research and the data collected.

"Classi in rete" was experimented for the first time in Italy in Abruzzo small schools that adhered to the Movimento Nazionale delle Piccole Scuole. INDIRE, in collaboration with the Centre scolaire du Fleuve et des Lacs (Ministère de

l'éducation et de l'enseignement supérieur du Québec), Italian University Line (IUL), Ufficio scolastico Regionale (USR) of Abruzzo and an expert of University of Valle d'Aosta, is engaged in training and experimenting innovative methods to help small schools' teachers to overcome the limits deriving from remoteness (Mangione & Cannella, 2020; The training, addressed the processes underlying the principles of the "Classi in rete" model (Mangione, Pieri, Tancredi, & Nadeau-Tremblay, 2021), paying a particular attention to the development of problematization skills on the teacher side. This ability is to be considered as essential to ensure a good level of *questionnement* also by students and remote teams.

Starting from the theories that recall the importance of problematization skills for emancipation and transformation in group learning environment (Zang, Scardamalia, Reeve, & Messina,, 2009; Zang, Scardamalia, Lamon, Messina & Reeve, , 2007), and with particular reference to the studies that specialize on the processes of advancing of knowledge and progressive inquiry (Hakkarainen, 2003), the research focuses on the works concerning the problematization skill in teaching and learning community contexts and in particular on the types of problems that may emerge. According to Hakkarainen (2003), it is possible to distinguish between:

- Factual Problem: Questions to be answered with factual information (who, where, when, how many, etc.).
- Explanatory Problem: Questions satisfactorily answered with an explanation (why, how, what-if, etc.).

Successful knowledge building is characterized by the generation of explanatory questions. These types of questions are, in fact, those on which it is possible to activate the progressive problem solving. The analysis of the problems that emerged in the online discussion space through content analysis approaches, has the added value of detecting both the type and the level of complexity of the problems proposed by teachers. The development of a good problematization will help the teaching team in supporting the discussion processes in online classrooms through KF, and, at the same time, it will guide them in the analysis of students' production and in supporting the level of commitment in the construction of knowledge in a group (Zhang et al., 2009).

The teacher training in the "Classi in rete" experience, introducing the KB model and the KF online environment for later use at school, allowed teachers to formulate problems of their specific interest, fundamental in inquiry-based teaching processes. In this paper, in particular, we will try to answer the following research questions:

- In which thematic area are the problems identified by teachers regarding the use of the KB model located?
- What characteristics do these problems have?
- What is the most elaborate problem?
- What solutions are proposed with respect to the problem most elaborated?

Method

Participants

The "Classi in rete" project involved 12 small schools of Abruzzo, 11 digital animators, 31 teachers, 6 observers (school principals). The present study examined, in particular, the data of 22 teachers (20 F, 2 M) of primary and lower secondary school and among them 7 digital animators of the project network.

Context

The training, which took place from September 2020 until January 2021 in an on-line laboratory mode within an environment that integrated video conference spaces in Webe-ex, KF and twin design spaces, addressed the processes underlying the principles of the "Classi in rete" model.

The presentation of the KB model was managed through videoconferences and KF version 6 was used, whose analysis tools made it possible to trace the participants' discursive interaction. KF, indeed, is an online environment developed to support the production of knowledge (Scardamalia, 2004). KF provides specific spaces for discursive interaction called "view", where the members of a KB community can share their ideas, questions, and problems of understanding using notes, that is to say written messages. Participants can connect their contributes to the notes posted by the other members using the build-on function. Views, notes, and build-ons are stored in KF, allowing the researchers/teachers to have access to, and analyze members' discourses.

The activity included a preliminary training meeting only with the animators. Subsequently, a meeting was held for all the participants on the KB theoretical model and on KF and a second meeting in which a synchronous discussion activity was proposed in KF on the use of the KB model at school (phase 1) which developed in asynchronous mode (phase 2) for about two weeks. In the discussion activity teachers were asked to formulate problems of interest to them, in the form of questions to which possible answers can be found together, on the implementation of the KB model at school, considering the use of this model and of KF in their classes. Each teacher was therefore invited to publish the problem with the scaffold "I need to understand" in a note in KF, to read and interact with the notes containing the problems formulated by the other colleagues. The corpus of data is made up of 63 messages (notes + buildon) in the perspective of "Knowledge Building at school-teachers", of which 10 opening notes of corresponding threads.

Procedure

Of the 10 opening notes of the discussion threads, 9 notes containing the scaffold "I need to understand", as indicator of the intention to report problems to be discussed, were considered. As a note contained two problems, the analyzed problems were found to be 10. For each problem the following aspects were analyzed:

- the thematic area of the problem, based on categories emerging from the analysis of the content;
- the type of problem with reference to the distinction between factual and explanatory problems, proposed by Hakkarainen (2003);
- the level of elaboration of the problem.

Furthermore, by focusing the content analysis according to the Grounded Theory approach, for the problem with the highest level of elaboration, the solutions proposed by the teachers were identified.

Data analysis

Regarding the thematic area of reference of the problem, the identified problems were categorized by two independent judges with a degree of agreement of 90% in problems related to teaching, related to technology in general, related to KF, other. With reference to the type of problem proposed, the problems were categorized into explanatory and factual problems by two independent judges, with a degree of agreement of 90%. The identification of the most elaborate problem took place by detecting the number of build-ons of the thread containing each problem on the use of the KB model at school. The identification of the answers to the problem was carried out using the three phases of the Grounded Theory (Faggiolani, 2011) with the software NVivo11: open coding (creating the first categories from the analysis of the notes content), axial coding (creating more general categories from the first categories), selective coding (identification of the core category to which all the previously identified categories are linked).

Results

With regard to the thematic area, of the 10 identified problems, 4 concern problems relating to technology in general, 4 problems relating to teaching, 2 problems relating to KF. With respect to the type of problem under discussion, 7 problems were of an explanatory nature and 3 of a factual nature. The problem that has had the most elaborations (N = 10) refers to didactics and is of an explanatory nature and in particular concerns how to use the KB in the first classes of primary school. The note containing this problem had 5 first level responses of which three with the My theory (MT) scaffold and two with the New information (NI) scaffold (but one of these, in addition to information, also presents a solution), 2 second level answers of which 1 with the My theory scaffold and the other New Information, 2 third level answers of which 1 with the This theory cannot explain (TTCE) scaffold and one with the "My theory" scaffold. A total of 9 proposals for solution to the problem posed are put forward in the thread, which are identified through the analysis of the content based on the Grounded Theory approach: the results are shown in Figure 1.

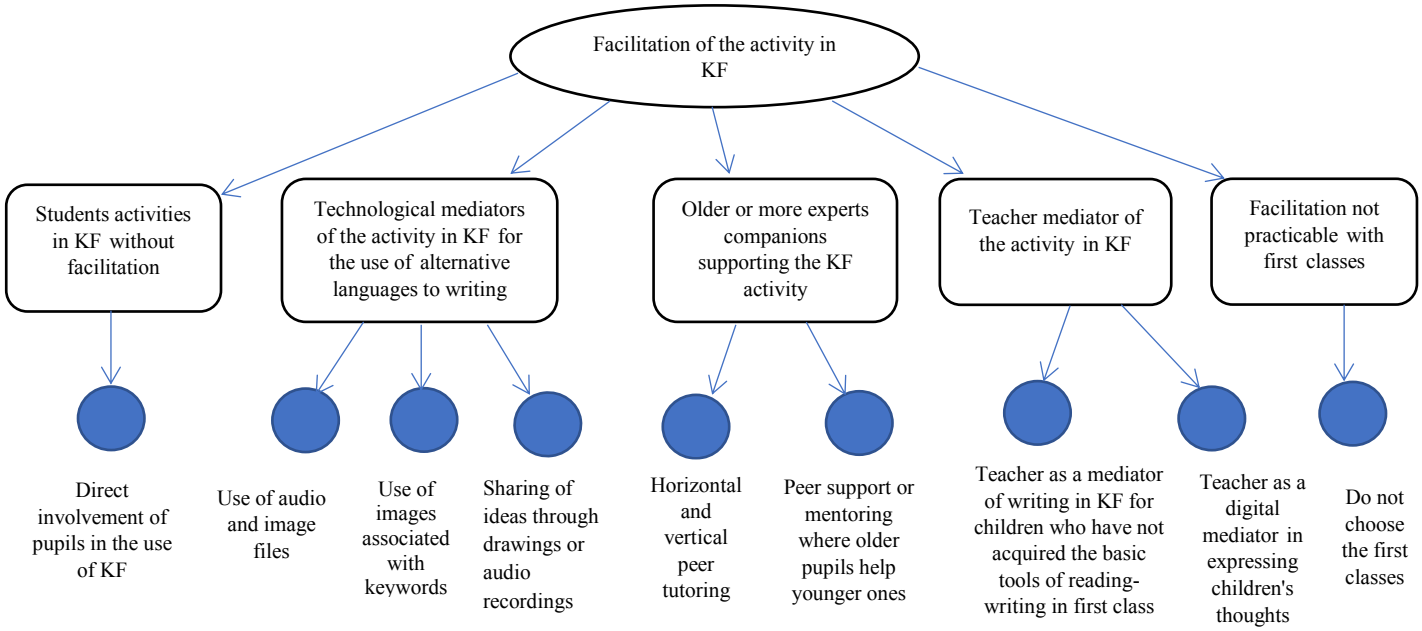

Figure 1. Solutions emerging through the discussion in KF

As can be seen from Figure 1, the theoretical coding identifies the "*Facilitation of the activity in KF*" as the core category, including five different areas (identified at the axial coding level), indicating some kind of possible facilitation strategies involving different actors or tools:

A) Student activities in KF without facilitation: it includes the solution indicated at the first level as: a) Direct involvement of pupils in the use of KF;

B) Technological mediators of the activity in KF for the use of alternative languages to writing: it includes the following solutions of the first level: b) Use of audio and image files; c) Use of images associated with keywords; d) Sharing of ideas through drawings or audio recordings;

C) *Older or more expert companions supporting the KF activity*: it includes the following solution at first level: e) Horizontal and vertical peer tutoring; f) Peer support or mentoring where older pupils help younger ones;

D) *Teacher mediator of the activity in KF:* it includes the following solution at first level: g) Teacher as a mediator of writing in KF for children who have not acquired the basic tools of reading-writing in first class; h) Teacher as a digital mediator in expressing children's thoughts;

E) Facilitation not practicable with first classes: it includes at the first level the following solution: i) Do not choose the first classes.

Discussion

The results showed the emergence of problems mostly of technological nature at a general or specific level (related to the KF online environment). Furthermore, the problems identified are mainly of an explanatory type. The more elaborate problem is about how to use the KB model in first classrooms of primary school. The proposed solutions focus on the issue of how to facilitate the use of KF for first grade students.

The explanatory nature of most of the problems formulated can be interpreted as an indicator of teachers' assumption of the knowledge building perspective, and therefore of the effectiveness of the training phase: according to Hakkarainen (2003), in fact, a construction activity of successful knowledge is characterized by the generation of explanatory questions. These types of questions are in fact those on which it is possible to activate the progressive problem solving envisaged by the KB model.

The prevalence of problems inherent technology leads to the hypothesis that KF was recognised by teachers as a central tool for mediating the activity of knowledge building, in line with what is indicated in the literature of the field (e.g Scardamalia, 2004). Consequently, teachers have tried to identify the best conditions for successful use of KF in their classrooms. This awareness of the relevance of KF may have been favored by the part of the training that made possible to use directly the online environment to facilitate discussion on the use of the KB model at school.

The strong attention paid by teachers to the technological dimension also emerges in the analysis of the more elaborate thread: although the teacher's question is focused on how to use the KB model with the first classes of primary school, the discussion shifts on how to facilitate writing in KF for first grade students. The proposed solutions can be placed along a continuum having as extreme poles, on the one hand a high level of students' agency *(Students activity in KF without facilitation*), on the other the impossibility of pupils of first grades to exercise agency (*Facilitation not practicable with first classes*). Between these two extreme positions we have found, first of all, some solutions based on the social interaction, with students more expert that-we hypothesize- can provide some scaffolds during the cooperation with their less expert companions. For second, other solutions are based on the idea of the mediation in the writing activity, realized through digital devices or by the teacher. It could be interesting to explore which kind of solution can obtain better results in order to promote students' agency in the first classroom of primary school.

The implications of the study results concern the relevance of a training that allows teachers to experience being members of a KBC. The use of KF as a space to bring out the problems of the possible implementation of the KB model in the classroom, as perceived by teachers, and the common search for solutions, in fact, introduces teachers to the work of knowledge building, by experimenting the epistemic agency (in identifying problems and working collaboratively to create solutions) and also a vision of the knowledge produced as a good created for the community (Scardamalia & Bereiter, 2010).

It is interesting to highlight, with reference to the studies inspired to the partecipatory design approach (Spinuzzi, 2005), that end-users (students and teachers) given the agency to contribute, can usefully become definers of learning spaces (Casanova, Di Napoli, & Leijon, 2018). So, giving epistemic agency to teachers on how to implement KB in classroom,

may imply that they can design a more effective and situated KB environment for their students. In addition, this opportunity could help teachers to recognize to their students the cognitive responsibility of the knowledge building activity, allowing them to define the problems on which to carry out an inquiry activity in the classroom. Finally, the training experience created could help teachers to promote students understanding of the focus of the activity on building collective knowledge useful for the community and not only on individual learning.

Future development of the present work could focus on how the analysis of the content of the problems and of the proposed solutions, emerging in the discussions of the teachers in KF during the training activity, could help to identify the most promising solutions to be used by the teacher in the implementation of the KB model in the classroom. In addition, following a partecipatory design approach, it could be interesting to explore how to involve students in exploring problem and solution in order to design an effective implementation of the KB model in classroom.

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Analysis of Knowledge Forum Analytic Tools to Support Progress Bar Initiative

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Abstract: There are various tools on the Knowledge Forum that provide different insights to students' behavior. Sometimes, these insights offer glimpses of a student's mindset and understanding towards Knowledge Building. In the first part of the paper, we aim to briefly introduce the functionality of the existing tools on Knowledge Forum. All the existing tools are in ways connected with the 12 Knowledge Building principles and offer unique value for student portfolio assessment. However, each of the tools function separately thus creating inefficiency for teachers to utilize the information. Thereby, the second part of the paper introduces a proposal that will combine all tools into one, the Progress bar. Specifically, the Progress Bar is a theoretical tool that combines all the valuable insights from different tools in its simplest form. In addition, the design of the progress bar framework aims to increase student engagement through the uses of game elements. As well, during a period of online learning where self-monitoring can be quite difficult, we propose as a way tool for self-monitoring where students can see how well they are progressing through the term and a one stop for teachers to use all extracted data from the existing tools.

Introduction

Knowledge Building is a principle-based driven theory designed to allow students to treat education as a knowledge creation enterprise (Scardamalia, 2017). Alongside Knowledge Building is Knowledge Forum which supports Computer Supported Intentional Learning Environments (CSILE) which is an online forum that fosters knowledge building collaboration through threaded discourse (Scardamalia, 2017). In order to support principle-based learning, Knowledge Forum includes analytics to support knowledge creation that automatically works in the background while users are using it. Knowledge Building was created based on social constructivism ideologies, meaning that the Knowledge Forum analytics in turn reinforce social interactions between different groups to promote knowledge creation (Scardamalia, 2002; Kim, 2013; Derry, 1999; McMahon, 1997). For example, by using the "Word Cloud" tool, teams can use these keywords to go into other design teams around the globe searching for commonalities thus assisting users to bridge different communities together to collectively work on advancing their ideas for the greater good.

In education, van Aalst and Chan (2007) found breakthroughs in formative assessment through electronic portfolios. In general, a portfolio refers to a collection of all the important assets of an individual's work in a specific area. In a Knowledge Building classroom, these portfolios represent a platform for students to self-reflect upon their best individual and group contributions, and progress to a knowledge creating community. Furthermore, the criteria developed for assessment conceptually includes the twelve principles of Knowledge Building but is simplified to adapt to the complex system (van Aalst et al, 2007; van Aalst et al, 2003). Overall, knowledge building portfolios must include both content and inquiry (Lee et al., 2005), thus a student must provide an explanation in addition to their selected artefacts explaining their selection and significance.

In addition to knowledge building portfolios, Knowledge Forum analytics can also play a role in supporting student-directed assessment. As many of the Knowledge Forum analytics were designed to support the twelve principles, for example, the tool "Idea Building" displays all the build-on notes to and from the selected author which supports collective responsibility, democratizing knowledge, community knowledge, and idea diversity. Students can also use these analytic tools to prove their Knowledge Building contributions and progress throughout the course quantitatively. However, quality is just as important as quantity meaning that these analytics can also act

as a stepping stool in helping guide student explanations when writing their portfolios. Therefore, moving forward with student-directed portfolio assessment, this proposed study will focus on graduate-level students to use Knowledge Forum analytics in assisting in writing their portfolios.

Knowledge Forum Analytic Tools

Embedded in Knowledge Forum 6 are several analytic tools that provide quantitative data that can be used to support principle-based assessment. We examined all embedded analytic tools then compared their technology to the twelve principles in order to determine how these analytic tools can support assessment.

Table 1: Summary of all analytic tools according to their functions related to the 12 Knowledge Building Principles

Principles	**Scaffold Growth**	**Activity Dashboard**	**Time Machine**	**Lexical Analysis**	**Word Cloud**	**s2viz(beta)**	**Idea Building**
Symmetric knowledge						✓	
Knowledge Building Discourses	✓				✓		
Community knowledge, Collective Responsibility						✓	✓
Idea Diversity	✓	✓		✓	✓	✓	✓
Rise Above				✓			
Epistemic Agency	✓	✓					
Democratizing Knowledge	✓	✓				✓	✓
Pervasive Knowledge	✓						
Concurrent Transformative Assessment	✓	✓	✓	✓	✓	✓	✓
Improvable Ideas	✓			✓		✓	
Constructive Uses of Authoritative Sources	✓			✓			
Real Ideas and Authentic				✓	✓		

Problems							

Scaffold Growth

The Scaffold Growth is a tool that analyzes the number of scaffolds used depending on the selected view and the selected user. This tool provides quantitative data on each number of scaffolds used where depending on the scaffolds developed for each class, it allows the instructors to get a general sense of how the students are responding to the classroom. For example, if more “Design Mode” scaffolds are used than “Reading Response” scaffolds, this could be a sign that students are more so engaging in design mode rather than potentially belief mode (Scardamalia et al, in press). However, because the data provided is only quantitative, it opens the possibility for students to “game” the system and purposely utilize the “correct” scaffolds during their portfolio self-assessment. The problem of inaccurate use of scaffolds remains unsolved now.

Scaffold growth supports Knowledge Building principles such as “Knowledge Building discourse”, “Idea diversity”, “Epistemic agency”, “Constructive uses of Authoritative sources”, “Democratizing Knowledge”, “Pervasive Knowledge” and “Improvable Ideas". This tool allows both educators and students to determine whether or not students are engaging in “design mode” discourse and how much engagement there is. For example, Costa et. al (2020) found that when students were reflecting on their participation, the scaffold growth tool allowed them to realize that there was an improvement from using individual personal pronouns to plural pronouns indicating growth. Overall, the frequency of certain scaffolds being used provides opportunities for metacognitive thinking for both teachers and students.

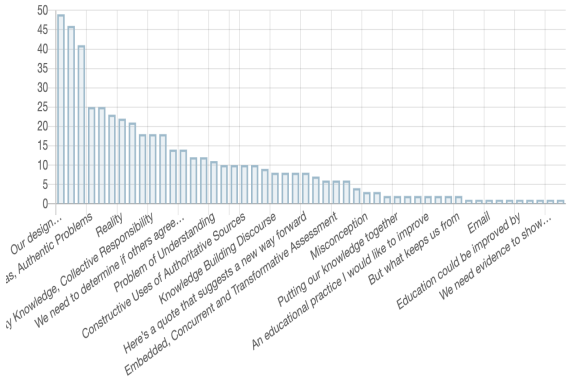

Figure 1: Picture of the scaffold growth graph

Word Cloud

The Word Cloud tool represents the most common words that are being used in each view. The “bigger” the word is displayed, the more common that word is being utilized in the selected view. Based on the popularity of the words being utilized in user’s notes, it can be an indicator for instructors to determine if students are engaging with the readings, design iterations, and Knowledge Building discourses. If we see great similarity between students' word clouds, we can assume students are engaging in knowledge building discourses. The differences in the word cloud between different time periods will reflect idea diversification. We shall see a clear difference between a student's word cloud if students have improved or “move forward” with his/her idea. Similarly, to the Scaffold Growth tool, it is another tool that is based on quantitative data which opens up the possibility for students to “game” the system.

Similarly, like the Scaffold Growth tool, both educators and teachers can use this tool as a reflective piece to understand certain words that they have been focusing on. For example, one can compare the current words being used to the curriculum to ensure that students are on track with their learning. Such data can be seen as a metric for transformative assessment. Depending on the words that appear in the cloud, we can also make assumptions with the student's current mindset in terms of the principle, real idea, and authentic problems. Overall, the Knowledge

Building principles that the Word Cloud supports are “Knowledge Building Discourse”, “Concurrent Transformative Assessment” and “Real Ideas and Authentic problems”

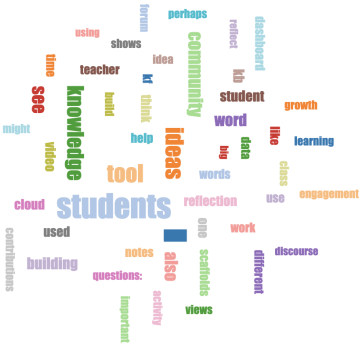

Figure 2: Picture of what the Word Cloud tool produces.

Idea Building

The Idea Building tool reflects the student's current collaboration level with the community. The tool reveals the number of original and “build-on” notes written by the selected user and the number of notes “built on” to the selected user from others. These three aspects cover most of the activity on Knowledge Forum and gives opportunities for students to see the full picture of their individual collaboration level of the community as well as their connections with their classmates who are labeled anonymously. The “in” and “out” flow of ideas is identified by the colour green and red respectively. The number of arrows means the number of interactions between different members. The width of the arrows indicates the amount of exchange between one member. The tool also records the growth of the collaboration level at different time frames, offering insights for co-current transformative assessment if needed. Similarly compared to the above analytic tools mentioned, the tool is based on quantitative data.

The Idea Building tool supports Knowledge Building principles “Symmetric Knowledge Advancement”, “Community Knowledge”, “Idea diversity”, “Democratizing Knowledge” and “Concurrent Transformative Assessment.” For example, community knowledge can be seen in this tool as the number of arrows we have for the community. If every person is connected, the community is well engaged, hence increase the chances for community design mode. The larger the arrow, the more knowledge or idea is being shared and this relates directly to democratizing knowledge.

This tool can be used as a self-reflective tool for both the educator and the participants understanding their participation level. It is noted that the user is only able to identify themselves but not others as it is anonymous for privacy. On the other hand, educators and/or instructors can identify all students’ understanding. By looking at the differences in participatory level around different users, instructors will be able to get a good grasp on whether symmetric knowledge advancement or democratizing knowledge is occurring within the community.

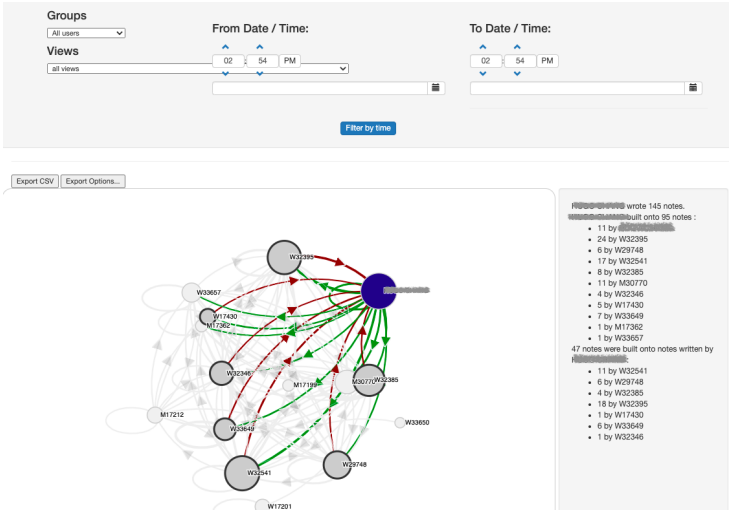

Figure 3: Picture of the Idea Building tool with the colour arrows indicating interactions

Time Machine

The time machine tool records all activities occurred in a view. The history of a view offers reflexivity to one's knowledge building process. The main purpose of the tool is to record each time a new note is posted in the selected view. The time belt at the bottom of the browser shows the number of different activities happening in each time frame; when a note is posted and where on the view. This tool allows users to identify the "rise above" moments or change of directions that impacted the community visually speaking. Since users post their notes asynchronously, if multiple activities occur after a while of not logging in, visually speaking it may be overwhelming. Therefore, this tool can help students "rewind time" and understand and locate the origin of trends.

The Knowledge Building principles that this tool supports are "Concurrent Transformative Assessment" where the instructor can observe how certain views on Knowledge Forum have changed overtime determining how consistent the activity on Knowledge Forum has been.

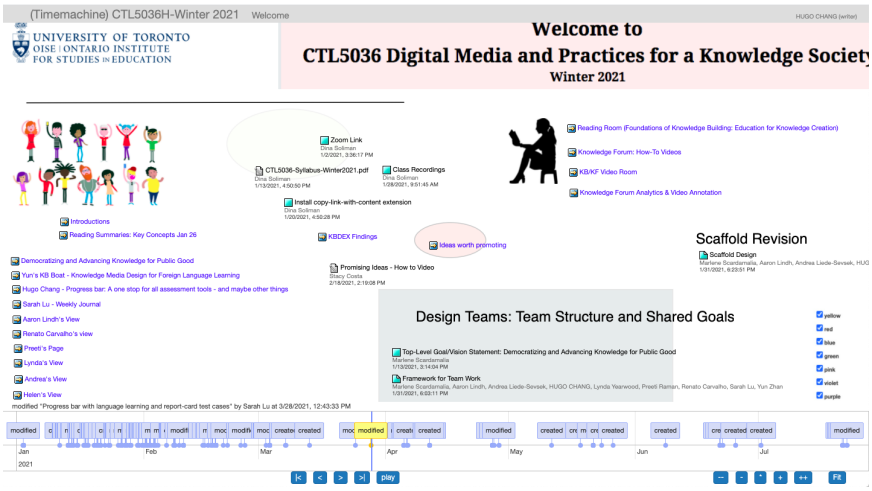

Figure 4: Screenshot of how the time machine function works

Activity dashboard

The activity dashboard tool offers an overview of all activities on Knowledge Forum from all users and users can choose to see their own activity on any views of their choice. The top right corner of the page will reveal three major activities which include the number of notes modified, notes read, and notes written. For the main

section, the tool arranges the community members with the most activity to the least activity in each view at different time frames. This function connects with the notion of collective responsibility because it shows where users are currently standing compared to the rest of the community. The tool also shows a complete history of all the activities the users conducted including the type of actions on each note and when it occurred. The activity dashboard can also serve as an embedded and transformative assessment tool for the course instructor as well as a self-reflection tool for the student to improve his/her engagement level.

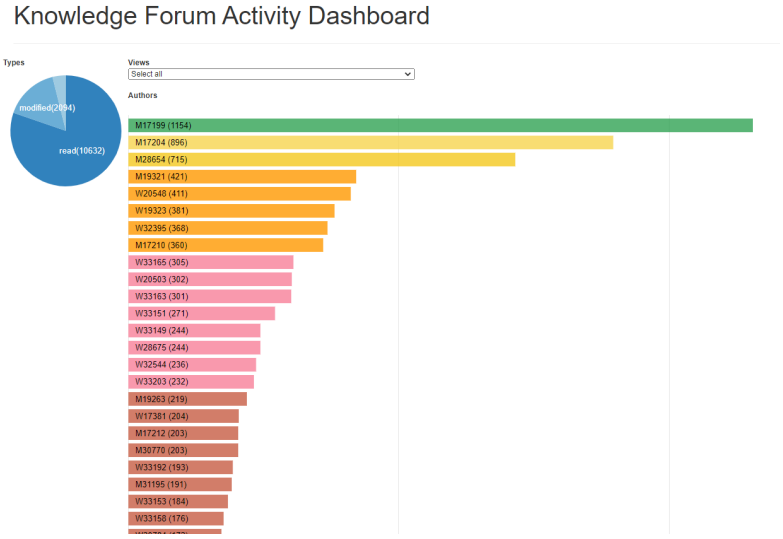

Figure 5: A screenshot of the activity dashboard

s2viz(beta)

The s2vic tool offers a complete image of the social interactions for Knowledge Forum. The interaction is measured by the number of times people read your notes and the number of times you read notes from different people. The tool shows a bar chart at the beginning indicating when the activities occurred. The level of reading activities tells us whether the community is sharing knowledge effectively. There could be many notes produced but little activities in terms of reading. If this is the case, the community is not operating at its optimum level. Meanwhile, if reading activity shows great level, we should expect high motivation and engagement from students. This relates to epistemic agency because students are in control of their actions in this case.

If read activity continue to maintain across the semester time, we view this as an indicator for idea diversity. There needs to be new ideas appearing for students to keep coming back and read the notes. Branching out from old ideas or brand-new ideas are signaled from reading activity level.

At the bottom, we see a circle of interactions and the width of the links signal for the frequency or connectivity each user has with one another. The tool offers insights regarding the level of engagement on Knowledge as well as the strength of connectivity between each student. To become a responsible collective community, strong connectivity with each member is essential and this tool can tell the story. This aligns with the collection responsibility knowledge building principle. Improvable ideas rely on having high students' activities. This tool is an indirect indicator to understand the direction of the ideas, whether is it branching out or stagnating. If we use this tool with other tools, for example, word cloud, we can determine if greater activities are improving students' ideas. It can also be used for assessment purposes.

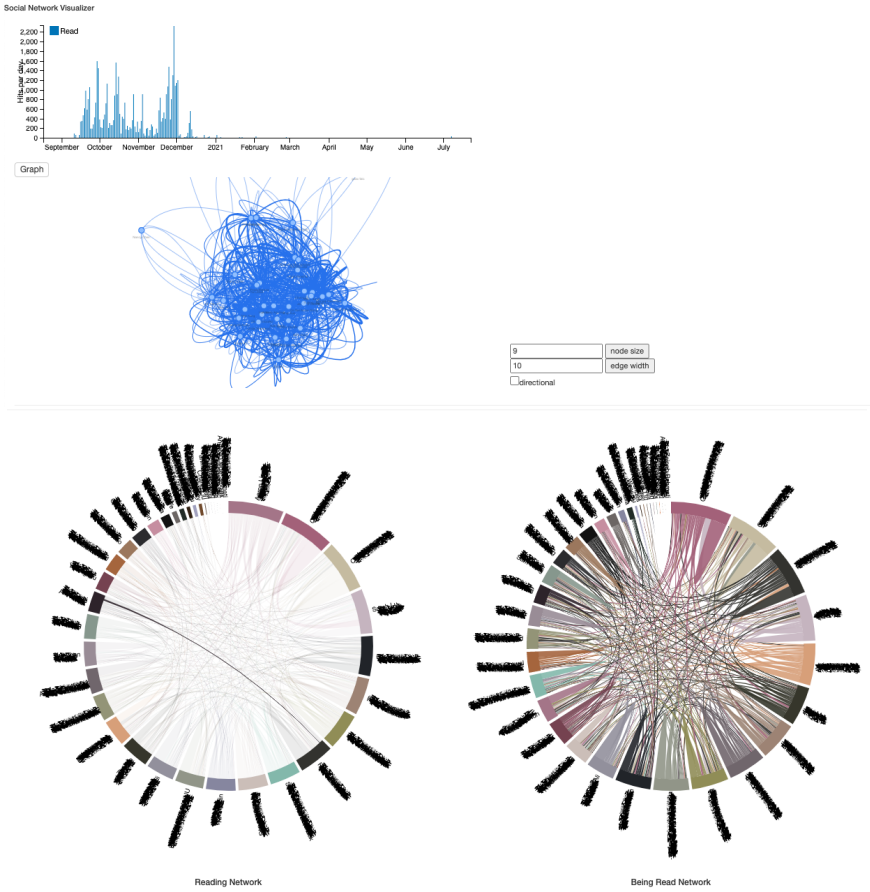

Figure 6: Picture of what s2viz(beta) produces.

Lexical Analysis

Lexical Analysis is a keyword finding tool. Students can find the frequency which the word shows up in a view as well as the notes that contain the word. The tool allows multiple words to be searched in one action, making assessment with keyword usage convenient for the teacher. Information can also show up in a form of bar chart or radar chart to provide visuals for different types of learners.

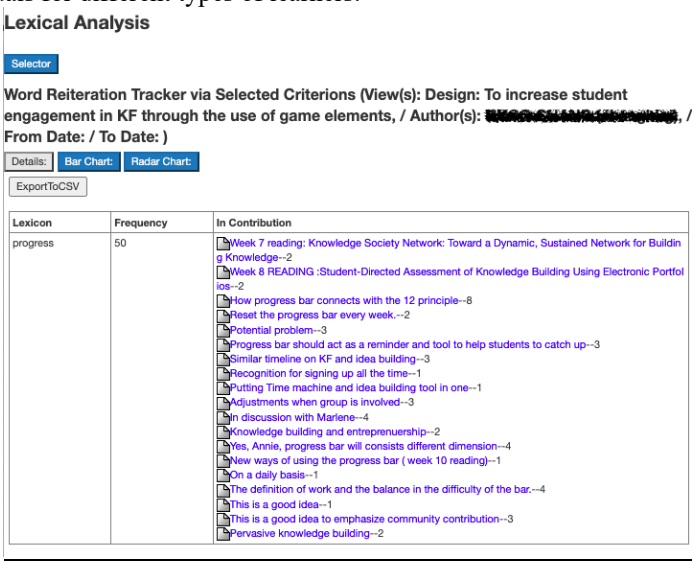

Figure 7: Picture of what Lexical Analysis produces

Our Research Proposal

Based on our assessment and review of all the current embedded analytic tools, each analytic tool supports various aspects of the twelve Knowledge Building principles separately and on a quantitative level. The way these tools displays student information is not user oriented. Teachers may have to click onto multiple tools for the same student to obtain all useful information and this process is tedious for large class size. We propose a tool that has an all-in-one function to support the functions of the current tools mentioned above to create an overview of student's engagement level on Knowledge Forum. We call this the Progress Bar. The functions taken from the tools will be set in the progress bar as various dimensions. These dimensions represent the information that is gathered by the existing tool on the Knowledge Forum, thereby the tool is a grouping of all the analytic tools. Each dimension will be set according to the expectation from the instructor. For example, students might be asked to provide more than 15 notes per week on Knowledge Forum for participation purposes. The 15 notes will be translated into ⅙ of the portion of the progress bar, and the same will go for other dimensions as well. The instructor will begin by setting specific expectations of each dimension however often they prefer, and students will get to choose to increase or lower their own personal goals based on the instructor's expectation and need of the community. In doing so, students will be on track of his/her engagement level and they are also granted a freedom to choose their level of contribution. Such freedom aligns with the principle epistemic agency because students are the ones to chart their way for engagement level in the course. In combination with both the progress bar and Knowledge Building pedagogy, a more coherent knowledge building classroom may emerge.

Background of the progress bar

The progress bar design is based on the assumptions that game elements can help students stay motivated and engaged. The effectiveness of game-based learning has been reviewed in many literatures and the results are mostly positive. Both Mayer and Johnson's (2010) review, and Vogel et al. (2006) showed that computer games can improve spatial cognition and attitudes, respectively, toward subjects like math and science. Digital games contain traditional game elements that enhance student engagements. The progress bar tool adopted several game elements reviewed by the Dicheva et. al (2015). The literature reviewed 34 papers reporting empirical research with multiple filters from seven different database, including ACM Digital Library, IEEE Xplore, ScienceDirect, SCOPUS, Springer Link (books), ERIC, and Google Scholar. Progress is one of the elements identified to be common and effective in educational gamification. Other elements such as the freedom of choices, social engagement loops, customization, goals, visible status, and time restrictions were also integrated as part of the progress bar tool. In the process of creating the tool, we see connections between some of these elements with the 12 knowledge principles and could possibly work well in the online knowledge forum setting. For example, freedom of choices aligns with epistemic agency in ways that offer students the freedom to negotiate a fit between personal ideas and ideas of others. Students enjoy the freedom to discuss or lead discussions on Knowledge Forum in different directions. In the progress bar context, freedom of choices appears in a form of student's goal setting for each dimension belonging to his/her progress bar and they are rewarded visually after performing an activity in the forum in a form of increment in the bar. Students get to choose the number of activities they wish to complete for the week. Even if students overachieve in one dimension, the progress bar will take their activity into consideration and adjust the increment accordingly.

The aim of the progress bar is to increase student engagement on Knowledge Forum using different game elements. We believe engagement level has direct correlation with student's understanding of knowledge building principles. In addition, there may be several benefits to implementing such a tool in the forum. The first benefit for the tool is that by completing the progress bar each week, students are engaging in Knowledge Building principle practices. For example, functions like setting your own goal for activities on a knowledge forum is related to epistemic agency and built-on to others is practicing "community knowledge collective responsibility". Though we acknowledge the problem with quantity versus quality may exist in this context, the reviews from Dicheva et. al

(2015) show encouraging results for game elements in computer application. The evidence suggests that quantity in student responses increases with no significant reduction in the quality.

The second benefit is that the progress bar can act as a reflection tool for students to assess and monitor their progress. The study conducted by Van Aalst and Chan (2007) show how using student portfolio, a formative student directed assessment approach, on Knowledge Forum gives epistemic agency to student's own learning. The portfolio is also a form of transformative assessment that sets expectations and guidance for future knowledge advancements. We view the progress bar tool as a complementary tool for the student portfolio. It offers real-time progress each time students do action on Knowledge Forum. Students get to see how their actions affect the progress bar, as well as how others influence their progress bar with built-on notes. All their activities are organized and stored in the Knowledge Forum for future reference as well. The information offers insights for students to create a more comprehensive portfolio, hence, further increasing the dynamics for "embedded and transformative assessment".

The third benefit the progress bar offers is the regulation of activity. The progress bar enables the minimum engagement level and guides the types of actions desired on the Knowledge Forum. Ultimately, the goal of Knowledge Forum is to create a platform which allows students to engage with one another to understand knowledge building principles. The discourses are archived for both teachers and students to review later, however, one of the difficulties is the lack of content on knowledge forum to formulate a good portfolio. For example, students often have difficulty identifying good clusters of notes to provide evidence for their understanding of the principles. This may be that students engage in activities beyond the Knowledge Forum. But since physical meetings or other mediums may not record the progress of knowledge building, teachers fail to see the process of student growth. Another reason may simply be that students have not spent enough time to engage with Knowledge Building. De-emphasizing instruction is one of the characteristics for Knowledge Building. Yet, students with no experience with Knowledge Building may treat this form of freedom as an opening to procrastinate, leaving little or no content for portfolio and design experiments. Regulated activities can enable the minimum level of engagement so that students have enough content to reflect their learning. While some may argue that regulated activities go against the value of minimum instruction in Knowledge Building, we believe both can co-exist. No instruction does not mean students have the freedom to not engage and regulated activity does not mean students can only engage in one way. The progress bar is only a way to help student to self-organize their activities on the Knowledge Forum and provide insights for reflections.

Assessment

One paper by Tong and Chan (n.d.) shows that there are possible relationships between principles and regulated activities in the knowledge-building environment; principles may help guide the use of personal and collective regulation for learning and knowledge advancement. The progress bar creates a framework for regulated activities in the knowledge building environment. These activities can also be considered as Knowledge Building practices. For example, building onto someone else's note helps increasing the person's progress is an act for collective responsibility, symmetric knowledge advancement. Having built-on from others mean that your idea is improvable. If notes are built-on multiple times by different parties, there are knowledge building discourses happening. All these actions will be recorded. The reward is the increment students receive from performing actions in the forum, as well as additional material for their portfolio. We hope that the progress bar can contribute value to the three types of regulated learning proposed by Järvelä and Hadwin (2013), self-regulated learning (SRL); co-regulated learning (CoRL); and socially shared regulated learning (SSRL), that we see in Knowledge Forum. The three types of regulated learning guide not only the students but also teachers when assessing student's engagement. The progress bar is compiled with different actions that reflect the three types of regulated learning. By there, we see a possibility of using the progress bar to enhance student behaviour assessment. Teachers can combine both progress bar achievement and student portfolio to form a complete picture of a student's understanding on Knowledge Building.

This will be particularly helpful for an online environment where students have found difficulty in self-regulation. This pilot project will test out the progress bar in an online graduate course where students will be using Knowledge Forum. The progress bar will be implemented in Knowledge Forum where both the instructor and the students can test out the usability of the progress bar and through design-based methodology, improvements will be made upon feedback from students and from instructors. Based on the continual feedback, our goal is to eventually have the progress bar embedded into Knowledge Forum which can further be improved to fit different contexts and needs.

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Object-Centered Sociality in Knowledge Building

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Keywords: sociality; knowledge objects; epistemic cultures; knowledge infrastructure

Introduction

Knowledge Building (KB) has three fundamental premises: (1) ideas are "real things," (2) students can take high-level epistemic agency, and (3) students have greater chance to improve their ideas by working as a collective (Chen & Hong, 2016; Scardamalia & Bereiter, 2014). As a unique educational model, KB envisions classrooms to parallel knowledge-creating organizations such as research laboratories and R&D units of companies. While grade-school students may not be tackling the most challenging issues in climate science or quantum computing, KB's ambition is to engage them in epistemic practices important to creative endeavors in knowledge-creating organizations. To this end, a set of guiding principles have been created to guide pedagogical and software designs (Scardamalia, 2002). Following these principles, colleagues have designed pedagogical strategies such as opportunistic collaboration (Zhang et al., 2009) and software tools such as the Promising Ideas tool (Chen et al., 2015) to facilitate emergent knowledge processes that center on student ideas (Hong & Sullivan, 2009). These efforts are essentially about creating social, temporal, spatial configurations, as well as favorable dispositions to learning, to create a classroom culture where epistemic practices (such as progressive problem solving) are upheld (Lin & Chan, 2018). Reflecting the intricacies and complexity of implementing KB in classrooms, the *Social Infrastructure Framework* lays out multiple dimensions of classroom structures that need to be considered, including cultural beliefs, practices, socio-techno-spatial relations, and interaction with the "outside world" (Bielaczyc, 2006). To implement KB, careful attention needs to be given to the socio-technical, socio-cultural, and spatio-temporal configurations, which are proven to be important for the inner workings of research laboratories (Knorr Cetina, 1999).

To contribute to this area of work, this paper sheds light on *object-centered sociality* (Knorr Cetina, 1997) as a fundamental aspect of knowledge building. Rather than limiting the definition of *sociality* to human relations, Knorr Cetina (1997) argues that "these object worlds need to be included in an explained conception of sociality and social relations" (p. 9). This is especially true for the knowledge society, where knowledge processes and social processes are largely inseparable. Knowledge work is largely mediated by knowledge objects, which could be tangible (e.g., the Large Hadron Collider) or intangible (e.g., supersymmetric theories). In some cases, these objects transcend a person's lifetime, national boarders, or disciplinary boundaries, giving rise to collective conventions and epistemic cultures that shape knowledge practices (Knorr Cetina, 1999). While KB has a long-standing interest in conceptual artifacts (Bereiter, 2002), a heightened analysis of *object-centered sociality* can be generative, surfacing new design principles and analytical strategies. This paper is structured as follows. I first explain the concept of object-centered sociality and its connection with KB. I then discuss potential ways this concept could be applied to KB.

Object-Centered Sociality

In knowledge work, objects of interest to workers, or epistemic agents, are not limited to material objects (e.g., a bridge, a photocopier) but also include "epistemic things" that are at the center of inquiry and in the process of being materially defined or represented (Rheinberger, 1997). In contrast to a material object that is often perceived to be stable, transparent, and unproblematic, objects of knowledge are always conceived of as being open, opaque, incomplete, question- generating, and complex (Rheinberger, 1997). The open, ever-unfolding nature of knowledge objects creates a "structure of wanting" among epistemic agents, or subjects, who attempt to improve their understanding to become less partial and inadequate, by creating, sharing, and working around representations of the objects. According to Knorr Cetina (1997), "objects of knowledge ... are the goal of expert work; and they are also what experts, scientists, etc. regularly profess themselves to be interested in, attracted by, seduced into and attached to" (p. 12). These knowledge objects (in Popper's *World 3*), as well as their representations in physical objects (in *World 1*), create demands for human labor, attracting humans to form groups, invent tools, and build complex infrastructures to better understand them. The never-ending incompleteness of knowledge objects, characterized by Knorr Cetina (1997) as "an open drawer filled with folders extending indefinitely," creates chains of "wantings" among the subjects so that they continue to organize around these objects.

The notion of *object-centered sociality* is based on the intense relations between humans and objects in knowledge work (Knorr Cetina, 1997). It rejects a fixation on interpersonal relations and includes human–object relations in the discussion of sociality. At the individual level, object- centered sociality expands a traditional cognitive interpretation of knowledge work to illuminate the libidinal aspect of object–human relations (Knorr Cetina, 2001).

Epistemic objects trigger a form of desire that is destined to remain partially unfulfilled because the objects would never be fully understood (Knorr Cetina, 1997). At the collective level, object-centered sociality explains the formation of social structures, collective norms, and knowledge infrastructures around knowledge objects. Object-centered sociality is related to the Vygotskian notion of *mediation*, which posits that human psychological processes are mediated by tools and signs (Vygotsky, 1978). However, object-centered sociality goes further to highlight the *reciprocity* between objects and subjects in that the "lackings" (of objects) and "wantings" (of humans) create conditions for social grouping, binding, and norming (Knorr Cetina, 1997).

The utility of the *object-centered sociality* concept is at least two-fold. First, it allows researchers to recognize important roles played by objects in knowledge processes. It prompts researchers to consider "the binding role of objects, personal object ties, object-centered traditions and collectives, and object-created emotional worlds" (Knorr Cetina, 1997, p. 9). For example, Suchman (2005) describes the dynamic relations she had with the Xerox 8200 photocopier and how the photocopier's image shifts from a tangible product for customers to an object of inquiry that has multiple meanings for different groups (such as marketing teams, R&D groups, and external researchers). In the context of cross-disciplinary collaboration, the collective object (such as the possibility of a new sensor) acts as the organizer and motivator that create a collective that revolves and evolves around the common object (Nicolini et al., 2012). In their analysis, the collective object "introduces a form of a collective obligation toward it—an emotional affiliation that becomes a morally binding force among the co-researchers" (p. 619).
Collaborative work among these researchers is driven by the requirements of the central object, to a degree that social interactions among humans could not be understood without referencing the object (Nicolini et al., 2012).

The object-centered sociality concept could also inform design efforts. While the social networking platforms often depict themselves as services connecting people, what has become clear is the tremendous affiliative power of objects on these platforms. Posting a particular news article is a statement of one's stance, which triggers reactions from others and changes with human–human relations. Therefore, it makes little sense to leave out the objects from analysis because they mediate human interactions, travel through human–human ties, and alter human– human relations. Because of the significant roles played by knowledge objects in social software, there are wide-ranging design decisions one could make on the representation of knowledge objects and human interactions with and around them. Besides people- and group-based sociality, object-centered sociality also merits consideration (Bouman et al., 2007).

Object-Centered Sociality in Knowledge Building

The notion of object-centered sociality should sound familiar to Knowledge Building. Philosophically, KB is grounded in the Popperian ontology that recognizes the independent ontological existence of conceptual artifacts (Bereiter, 2002). As an idea-centered pedagogy, KB is focused on creating conditions for idea growth (Hong & Sullivan, 2009; Scardamalia & Bereiter, 2014). Students are enculturated to "befriend ideas" (Bereiter, *personal communication*), as experts do when wanting to work on an epistemic object (Knorr Cetina, 1997). Social organization of students can be based on their emerging interests (Zhang et al., 2009). Students are asked to consider promising ideas in their community (Chen et al., 2015) and reflectively inspect knowledge structures that emerge from their collective work (Tao & Zhang, 2018). To a great extent, sociality in KB is already assumed to be idea-centered.

Technological designs for KB also reflect an interest in supporting object-centered sociality. Knowledge Forum is designed to enhance "collaborative efforts to create and continually improve ideas" (Scardamalia, 2003). The focus on ideas (and their representations) is so intense that "human-centered" software features are lacking, or less visible, in Knowledge Forum. Reflecting Rheinberger's (1997) notion of "epistemic things," ideas in KB are always incomplete and improvable, with their representations—e.g., *notes*—able to exist in different *views* to meet different demands (Scardamalia, 2003). Interpersonal relations, such as replying and co- authoring, form around knowledge objects in different spaces. These human relations are important, for educational reasons, but somewhat secondary in comparison with idea improvement when designing knowledge-building environments.

The idea of object-centered sociality is also reflected—although implicitly—in the analysis of KB discourse. The socio-semantic analysis supported by KBDeX (Oshima et al., 2012) is one manifestation of object-centered sociality. In KBDeX, social ties among students are based on the shared vocabulary instead of social interactions. Drawing on KBDeX as an analytical infrastructure, social phenomena such as "rotating leadership" in a classroom is examined (Ma et al., 2016); students are regarded as leaders not because they write popular notes but when they bring multiple words (and ideas they embody). Student-facing analytics such as "Idea-Friend Maps" are also created using KBDeX so that students can reflect on the evolving knowledge structure (represented as word networks) and the social structure around ideas (Feng et al., 2019). Undergirding these analytical work is a nod to object-centered sociality, even though it is not explicitly addressed in writing.

Towards Infrastructures for Object-Centered Sociality

While object-centered sociality is already reflected in KB literature and design, it could be fruitful to bring it to the fore for heightened theorization, design, and analysis.

At a high level, we could ask the following question: *How can we design better infrastructures to sustain the objectual relations and harness such relations for sustained knowledge building?* In a particular KB context, this question could be further decomposed to a list of sub-questions. For example:

- What attitudes and dispositions towards knowledge objects are desirable?
- What technological infrastructure is needed to create meaningful representations of the knowledge object?
- What emotional infrastructure is needed to surface and sustain a community's relation with the epistemic object?
- What spatio-temporal configurations are conducive to productive epistemic practice around the object and its representations?
- What analytical infrastructure can help us make sense of and act on object-centered sociality?

Answers to these questions may differ across contexts and epistemic objects. For instance, high- energy physics and molecule biology require different objectual knowledge practice that gives rise to unique epistemic cultures, wherein huge detectors used in high-energy physics are humanized (e.g., being ill, behave badly) while natural organisms in microbiology are treated as machines; social organization is also remarkably different around these objects, with high-energy physics delegating epistemic agency to the collective, or "the experiment," whereas in molecule biology the lab leader is often in the spotlight (see Knorr Cetina, 1999).

In KB, efforts to harness object-centered sociality needs to recognize the existence of multiple adaptive systems—e.g., cognitive processes, teacher practice, information environments, and school systems—and the need to bring them to work together (Edwards et al., 2013). To illustrate the implications of object-centered sociality, I discuss three early-stage ideas. First, given a knowledge object may generate a deep emotional desire and intimate attachment for epistemic agents, the design of KB environments need to seriously consider stronger emotional infrastructure to harness emotional and affective states in knowledge work. KB research is already uncovering interesting emotional dynamics in students' knowledge work (Zhu et al., 2020). We need to intentionally design emotional infrastructure in KB environments to support students' expression of emotional reactions to ideas and further use of these professed emotions to advance knowledge work. Figure 1 presents an interface that extends the Promising Ideas tool to capture emotional dynamics when students interact with ideas.

Figure 1. A sketch of a student leaving emotional markers when reading an article.

Second, we need an expanded list of representational devices in order for knowledge objects of different types, or sizes, to materialize into tangible artifacts. So far the most popular representations are *notes* and *views*, which correspond to individual ideas and a collection of ideas intentionally organized into different structures. Besides text (a dominant medium for expressing ideas), the drawing device provides a powerful medium for depicting the epistemic object especially when writing becomes a challenge (Gan et al., 2021). In additional to intentionally created structures of ideas in a view, the Idea Thread Mapper augments students' capability in grappling with emergent knowledge structures (Zhang et al., 2018). Latching on the notion of object-centered sociality, we can design new representational devices that do not only provide visual displays of a knowledge object but also dynamic rendering of its evolving status, including it "lackings," to elicit students' "wantings" and collective efforts. For instance, if a dynamic word network can be used as one representation of the knowledge structure, structural gaps between important terms in the network (see Figure 2) may suggest current gaps of understanding that need to be addressed (Hussein & Chen, 2020). We are especially in need of representations (besides these word networks) for larger knowledge structures that emerge from student discourse, representations that are more accurate and actionable projections (like a mirror) of the epistemic objects.

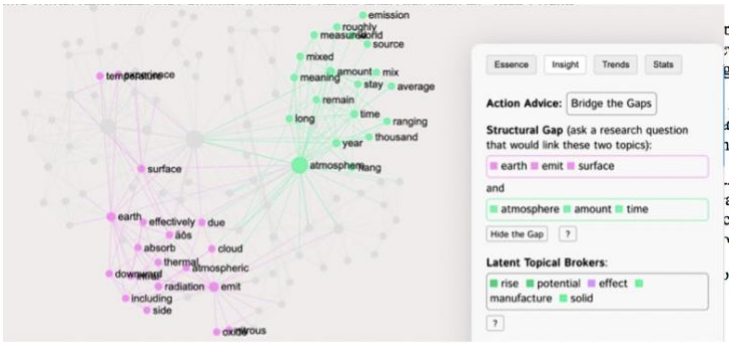

Figure 2. Text analysis showing a structural gap.

Finally, based on object-centered sociality, social network analysis of students without considering knowledge objects is missing an important piece of the picture. While such analysis may help a teacher identify students who are socially isolated in a KB classroom, it fails to recognize the objectual conditions of the social ties among students. Building on existing work on KBDeX (Oshima et al., 2012), it could be fruitful to model KB discourse as multi-mode dynamic networks so that features of the objects and artifacts are also considered in network analysis (Chen et al., 2021).

To conclude, in this paper I attempt to shed light on the concept of *object-centered sociality* developed by Knorr Cetina (1997) and discuss its utility for Knowledge Building research and design. Much work is apparently needed and you are invited to join the effort.

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Knowledge Building Infrastructure Principles: A Beginning Framework and Call-to-Action

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Abstract: As a design-centered innovation, implementations of localized Knowledge Building Communities have been guided by a set of principles that have been articulated and shaped over the past three decades. Still, many studies of knowledge building have not revisited the set of design principles as part of the informing cycle. In this short paper, we suggest that the KB community could benefit by more intentionally taking part in an informing cycle around the design principles, and we share findings from a recent study that we led that did just this. Though our findings do point to the integrity of the current set of principles, they also suggest several extensions. Furthermore, our findings point to the need to further develop a second set of non-idea-centered, infrastructure principles that support knowledge building efforts.

Keywords: KBCs, infrastructure, design principles, informing cycle

Education as a "design science": Goals, methods, and desired outcomes of research in the learning sciences

The notion of design is salient in the learning sciences and has been instrumental in articulating a unique set of goals, methods, and desired outcomes. As opposed to other scholarly communities focused on learning and education, the learning sciences were established to accomplish goals that transcend theory development. In a landmark paper entitled "Toward a Design Science of Education", Collins (1992, p. 4) argued that the study of education should be redrawn as a design science, i.e. as a scholarly endeavor intended to determine "how different designs of learning environments contribute to learning, cooperation, and motivation" with the goal of advancing the practice of teaching and learning. Like other design sciences such as aeronautics and AI, Collins envisioned a scholarly community with tangible real-world goals in mind — a vision that has largely materialized over the past three decades (e.g., Nathan & Sawyer, 2014).

As implied by their name, design-based research (DBR) *methods* — which emerged as a unique approach within the learning sciences community — are also oriented towards design. Typically, DBR is distinguished by its reliance on data extracted from real-world contexts and by analytic methods that have the dual focus of overcoming real-world challenges and advancing abstract theories (McKenny & Reeves, 2014). Contrary to experiments that are conducted in laboratories or other controlled environments, DBR adopts the view that learning environments are complex systems that must be evaluated in-situ. Due to this sensitivity to context, the theoretical approach underlying many DBR studies is inspired by a sociocultural view that sees learning as a situated activity distributed across a complex environment comprising individuals, communities, and tools (Brown, Colling & Duguid, 1989). Recognizing the uniqueness of each learning environment and the complex interdependence of the many elements that comprise them undermines simplistic notions of replicability — a cornerstone of classic methodologies in the social sciences that has recently been challenged (Open Science Collaboration, 2015). As an alternative form of academic rigor, DBR projects are often iterative, seeking to articulate generalizable results that are adaptable to other contexts, thus transferable but not necessarily replicable.

In light of the goals and methods outlined above, the *desired outcome* of research in the learning sciences is also unique. Rather than general scientific theories, the conclusions of DBR are often situated in the realm of Principled Practical Knowledge — knowledge artifacts that develop amid efforts to solve practical problems and are explanatory and generalizable to a certain degree. According to Bereiter (2014, p. 9), learning scientists have "largely abandoned the theory-into-practice model and followed the Wright brothers in creating Principled Practical Knowledge on the way to solving real-life educational problems." One form of Principled Practical Knowledge, known as design principles (Kali, 2006), is a highly desirable product of DBR, which seeks to go beyond plainly observable "surface procedures" that unfold in a particular learning environment and articulate the "principles of learning" that underlie them (Brown & Campione, 1994, p. 264). Being a form of Principled Practical Knowledge, design principles can be used by teachers and other practitioners to solve real-world problems, while also advancing

theories of learning. In the words of Bell, Hoadley and Linn (2004, p. 83; also cited in Kali, Levin-Peled & Dori, 2009):

> Design Principles are an intermediate step between scientific findings, which must be generalized and replicable, and local experiences or examples that come up in practice. Because of the need to interpret design-principles, they are not as readily falsifiable as scientific laws. The principles are generated inductively from prior examples of success and are subject to refinement over time as others try to adapt them to their own experiences.

Knowledge Building Communities: A principle-based approach

KBCs have been a central avenue of research for learning scientists since the field's inception (Scardamalia & Bereiter, 1991), and have been described as one of the longest running design experiments in education (Bereiter, 2006; Bielaczyc, Kapur & Collins, 2013). Inspired by innovative businesses, academic disciplines, and other communities that regularly engage in creative knowledge work, KBCs combine theory, technology and pedagogy to redesign learning environments as knowledge building enterprises. Notwithstanding their shared characteristics, KBCs are also intended to be highly local, leaving space for teachers and learners to determine exactly *how* to go about their knowledge work. This means that on the continuum between procedure- and principle-based pedagogical approaches, "Knowledge Building may well stand alone, far out on the principle-based end of the continuum" (Zhang et al., 2011, p. 266). Contrary to procedure-based approaches, which dictate to teachers and students precisely what to do, the principled-based KBC approach offers a set of design principles that must be adapted and translated into concrete procedures.

The purpose of the KBC design principles is to translate a Popperian theory of knowledge into everyday practice in real-world educational contexts. Popper distinguished between two types of knowledge that exist in two separate realms, or "Worlds": internal private mental processes, which he defined as "World 2", and out-in-the-world products of the mind that have been made public, which he defined as "World 3". According to this view, publicly accessible knowledge artifacts located in World 3 — problems, designs, languages, formulae, or even works of art and music — exist independently and can be developed in ways that their originators did not intend or foresee (Popper, 1994). The distinction between World 2 and World 3 and the notion that ideas in World 3 are malleable and improvable and that multiple people can collaborate to continuously advance them are the foundation for the KBC approach.

Traditional learning environments focus on World 2, seeking to change individual learners and the knowledge they possess, so that the learners themselves are the object of the learning environment (Sawyer, 2008). However, the primary focus in KBCs is on World 3, as learners seek to collaboratively advance publicly accessible knowledge. This Copernican shift, which repositions learners as agentive subjects who take responsibility for driving the knowledge building process forward, requires learners to embrace a design mode way of thinking that sees knowledge as situated, transient, improvable, and contingent (Bereiter & Scardamalia, 2003). Scardamalia and Bereiter (2016) use the metaphor of an "idea landscape" to describe the process learners undergo as they embrace a design-mode way of thinking and engage in knowledge building efforts. Rather than traverse a predetermined path across the landscape, KBCs invite learners to crisscross it in every which way, which deeply familiarizes them with the objects of their inquiry and empowers them to engage in real-world knowledge work, as they co-create and rise-above the landscape to develop new forms of knowledge based on those that already exist.

Roughly one decade after reporting on the first KBC, Scardamalia (2002, pp. 9-12) articulated a set of twelve ideas, which were later recognized as design principles, that distinguish KBCs from traditional learning environments and other learning communities. The purpose of the KBC design principles is to "serve an important regulative function for both teachers and students, helping to keep higher-level goals in mind" (Scardamalia & Bereiter, 2014, p. 403). There are currently four comprehensive formulations of KBC design principles that are primarily built on one another (Chan & van Aalst, 2018; Chen & Hong, 2016; Zhang et al., 2011; Scardamalia, 2002).

Elaborating the KBC design principles

For the KBC design principles to qualify as the kind of Principled Practical Knowledge that is one of the primary aims of DBR, the complete set of principles — including the explanations and examples used to elaborate them — should be updated regularly to reflect the empirical and theoretical advancements made by KBC researchers. This process has been called an *informing cycle* (Puntambekar, 2018), which is a hallmark feature of DBR whereby multiple studies over an extended period of time comprise a sustained effort to advance researchers' understanding of different aspects of an innovative learning environment. As Puntambekar (2018) states, multiple studies "along a trajectory can be designed to focus on design features, theoretical principles, or issues of implementation… Each study informs the

next study, and helps to cumulatively build knowledge about the many aspects of understanding an innovation in context". In many ways, KBCs represent a quintessential DBR trajectory that has flourished over three decades and yielded many successful real-world results along with advancements in theory and supporting tools. Updating the complete set of principles and how they are explained and elaborated in light of these advancements could contribute to the ongoing success of the KBC-approach trajectory.

To be clear, we are not suggesting that the design principles themselves have not been examined empirically. However, the way they have been elaborated and presented as a complete set intended to articulate the essence of the KBC approach should become a more intentional part of the informing cycle associated with the KBC design-based research trajectory. For example, Resendes, Scardamalia, Bereiter, Chen, and Halewood (2015) examined two visualization tools that gave group-level feedback to facilitate knowledge building metadiscourse. While appropriately noting the generalizability of their findings, their results showed the different ways that these tools supported strategic, epistemic discourse moves at the group-level. Building on the idea that in "knowledge-based and innovation-driven societies virtually all knowledge advances are group endeavors" (Resendes et al., 2015, p. 331), the authors' empirical findings suggested that group-level formative feedback should be part of KB assessment practices. Others have discussed this as well, and have built tools to examine group or community level discourse (Oshima, Oshima, & Matsuzawa, 2012). Yet the most relevant design principle on embedded and transformative assessment states that "assessment is integral to Knowledge Building and helps to advance knowledge through identifying advances, problems, and gaps as work proceeds" (Zhang et al., 2011, p. 269), without the individual or group-level refinements that this empirical research has suggested.

The gap in the informing cycle is not limited to one or two isolated cases. Zhang, Scardamalia, Reeve, and Messina's (2009) study demonstrated that opportunistic groups achieved a higher level of *collective cognitive responsibility* than other strategies for grouping learners. Chen, Scardamalia and Bereiter (2015) showed how additional instructions about "promisingness of ideas" scaffolded students' ability to *improve ideas*. Law and Wong (2003) analyzed students' contributions on The Knowledge Forum, looking for any enactments of the KB principles. Their analysis uncovered a "hierarchy of accessibility" (p. 65) that suggests a "developmental trajectory in knowledge building, with the less accessible principles being demonstrated only when the students have deep engagement in the learning process". Despite the extensive and rigorous empirical work that has been done to refine and elaborate on the KB design principles, none of these specific findings about opportunistic groupings, promisingness of ideas, or hierarchy of accessibility appear in existing formulations of the complete set of KBC design principles (nor has any rationale for excluding them been presented). The result is an incomplete informing cycle, meaning that the higher-level goals regulating the way that KBCs are enacted by practitioners and researchers may be dated or incomplete.

KBC design principles reconsidered

Considering all of this, we recently conducted a study intended to elaborate the existing set of KBC design principles (Cohen & Hod, 2021). Because we wanted to include additional student voices within the informing cycle, we asked two cohorts (n=45), grades 9 and 10, who were all first-time KBC participants to articulate their views of KBCs as part of their end-of-year assignments. We then conducted a qualitative analysis of their essays, and carefully compared them to the existing set of design principles. We found that most of what they had to say about KBCs was already articulated in one or more of the existing sets of principles. However, we also were able to extend the scope of each of the existing principles based on their essays. For example, one essay tied the notion of improvable ideas to a design-mode way of thinking; an idea that Scardamalia and Bereiter (2017) have identified as central to knowledge building but is not reflected in the existing set of design principles. Finally, we found 37 statements that we were unable to associate with any of the existing principles, which led us to formulate a new principle: *Belongingness to a community*.

Infrastructure principles and idea-centered principles: A promising idea?

Another takeaway from our study was that it may be constructive to consider whether there ought to be different types of KBC design principles. Specifically, in addition to idea-centered principles, there is a wide range of literature suggesting that knowledge building requires *infrastructure* to be successful. By knowledge building infrastructure, we mean the set of tangible (e.g. technological tools) and intangible (e.g. social norms) objects or processes needed to support knowledge building. In fact, many different approaches to support the emergence of KBCs in classrooms have been tried (Chen & Hong, 2016) and there is strong evidence that neglecting non-idea-centered infrastructure could be unproductive (Barron, 2003).

A great deal of scholarship on community-based learning environments has attended to these dimensions. There has been recent interest in developing the technological infrastructure of knowledge building, with Chen and colleagues developing the Idea Magnets Tool to further connect school and societal knowledge building enterprises (Amundrud et al., 2021). Recent research by Hod and Katz (2020) have considered some of the spatial supports

necessary to foster productive knowledge building. Carl Rogers (1969), an early proponent of the learning community approach, developed the theoretical grounds for the personal and emotional dimensions of learning, which has been applied in the context of KBCs (Hod & Ben-Zvi, 2015, 2018). Lastly, there are many suggestions that the social infrastructure for knowledge building is vital. For example, communities of inquiry include social presence as one of three aspects of learning in a community (Garrison et al., 2010). Researchers on groups have long recognized the inseparability of task and social functions, an idea echoed in the learning sciences about collaborative learning (Hand & Gresalfi, 2015). More specific to knowledge building, Bielaczyc (2006) has directly addressed the need for a social infrastructure, however these ideas have not made their way explicitly into any formulation of KB principles.

Taken together, we suggest that a secondary set of KB principles that include technological, spatial, personal, emotional, and social infrastructure principles could be articulated as supports for the current idea-centered principles. While some of these are embedded into the existing set of idea-centered principles, their distinction as knowledge building infrastructure could both clarify the existing principles and open opportunities to systematically explore new ones.

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Engaging Students in Collaborative Computational Thinking through Knowledge Building and Robotics

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Abstract: Studies show several benefits of using robotics in educational settings, including its positive effects on advancing computational thinking among students. This study is the first attempt to examine the extent to which elementary students engaged in computational thinking through robotics, employing knowledge building pedagogy and technology. The results show that students as young as age 10 have the ability to engage in computational thinking processes in a knowledge building robotics community, without a need for the teacher's guidance. The findings of this case study support and add a social dimension to the computational thinking process.

Introduction

Along with robotics technology development, researchers and educators in many countries, including Canada, Japan, South Korea, Taiwan, and the United States have employed robots to support education (Han, 2012). Several studies (e.g., Attard, 2012; Bauerle & Gallagher, 2003; Druin & Hendler, 2000; Jeschke, Kato, & Knipping, 2008; Khanlari, 2019) have shown that hands-on robotics is engaging, creates constructive learning environments that are suitable for a better understanding of STEM disciplines, has positive long-term effects such as attracting students to technological and scientific studies, and leads students to a love of STEM subjects. Educational robotics (ER) can also help students develop the skills needed for living in the digital world (Gura, 2012) including problem-solving skills, creativity, critical thinking, and collaborative skills (Alimisis & Kynigos, 2009; Barak & Doppelt, 2000; Bers & Portsmore, 2005; Chalmers, 2013; Vernado, 2005).

Literature also shows that educational robotics can be considered an appropriate tool for the development of computational thinking (CT) skills (e.g., Bers et al., 2014; Bottino & Chioccariello, 2014; Catlin & Woollard, 2014; Chalmers, 2018). However, there are only a few studies that focus on the implementation of educational robotics to develop computational thinking skills in classrooms (Chevalier et al., 2020). A recent meta-analysis shows that only four works between 2006 and 2018 focused on implementations of educational robotics in order to foster computational thinking skills in K-5 education (Hsu et al., 2018; Jung & Won, 2018; Shute et al., 2017). Also, Ioannou and Makridou (2018) conclude that there are only nine empirical investigations at the intersection of educational robotics and computational thinking in K-12. Most of these studies emphasized the role of teachers in developing computational thinking using robotics, and pointed out that there is a lack of "explicit teacher guidance on how to organize a well-guided ER activity to promote students' CT skills" (Atmatzidou & Demetriadis, 2016).

While most previous studies focused on the role of the teachers, the present study aims to examine the extent to which students in a student-centred community can practice computational thinking as they engage with educational robotics. The premise of our research is that computational thinking will truly have a transformative effect on student's futures if technical skills are accompanied by the skills required to explore ideas, generate theories, and design solutions (ISTE, 2016; Paniagua & Istance, 2018). Hence, our emphasis is not on the acquisition of coding or programming skills, but rather on how the discourse surrounding programming activities facilitates engagement with different computational thinking practices.

Knowledge Building Pedagogy and Technology

In order to create a student-centred environment, the knowledge building pedagogy was employed. Knowledge Building is an idea-centred pedagogy that considers students as epistemic agents who create knowledge through engaging in complex socio-cognitive interactions. (Scardamalia & Bereiter, 2003). Knowledge is viewed as a social product with students taking collective responsibility for the state of public knowledge and continual idea improvement (Scardamalia, 2002; Scardamalia & Bereiter, 2006). The community succeeds through the distribution of group effort across all members, not the concentration of efforts amongst a few individuals. Indeed, individual interests and expertise are complemented by those of the community as each individual tries to achieve both individual and community goals (Amar, 2002). Therefore, beyond ideas held privately by individuals, ideas should

be made available to the community as publicly accessible artifacts that can be discussed, interconnected, revised, and superseded (Scardamalia & Bereiter, 2003). This knowledge building discourse can be facilitated by the Knowledge Forum technology, which is specially designed to support advanced knowledge work (Scardamalia, 2004).

Scardamalia (2002) and Scardamalia and Bereiter (2006) presented 12 principles that altogether describe Knowledge Building. The principles are set forth to make knowledge creation more accessible to teachers and students and to enable the application of Knowledge Building in practice. The most widely used environment to support Knowledge Building and create collaborative networks in education settings is Knowledge Forum. (https://kf6.ikit.org). Knowledge Forum is a web-based discourse medium specifically designed to support the production and refinement of community knowledge to advance understanding of the world and effective action through social interaction (Scardamalia, 2004). In our study, we examine how two principles - particularly "idea diversity" and "concurrent, transformative assessment" were observed as students engaged with educational robotics within a knowledge building environment.

Settings and datasets

In this pilot study, participants explored math concepts while working on their robotics projects over the course of four months, one session a week. The educational robot

used was the Vex IQ, which provides the required resources to enable students with different skills to design, build, and program their robots. Each session lasted for 90 minutes, involving two components:

1. *Knowledge building circle*: For the first 20 minutes, students gathered around a horizontal whiteboard, named "TOGA" (Table of Great Achievement) where they were able to write their ideas and make notes of other student ideas. During this time, students were asked to update their peers about their progress on the task, express their success/failure stories, ask questions, and answer their peers' questions. Students were asked to enter the findings of the knowledge building circle into Knowledge Forum.

2. After the knowledge building circle, students were asked to divide into their groups and work on their projects for the remaining hour session. During this time, students engaged with hands-on robotics projects to code their robot and solve a challenge. While working on their projects, students were expected to enter their findings, challenges, issues, and breakthroughs into Knowledge Forum. They were also expected to ask questions and build on each others' contributions. During both components, the teacher provided minimal guidance to students.

Activities

The activity designed for this study focused on enabling students to explore geometric concepts using robotics. Different task cards were created, each describing a particular shape. Each group of students was given a card. Students were expected to first identify the shape on their car and then program their robots to draw the shape. Each team was provided with a chart paper and a marker to attach to the robot. There were three different tasks cards. For example, the description on the 'rectangle' task card was as follows:

1) Program your robot to draw a shape that:

- Has two sets of parallel lines,
- Has four 90 right angles,
- Has two pairs of congruent lines,
- Has a perimeter of approx. 200cm.

Dataset

Participants for this study included 16 Grade 5/6 (12 boys, 4 girls) in a school located in Ancaster, Hamilton. This school has two classes per grade, taking into account that in some classes two grades are mixed. As stated in the previous section, students' posted their contributions to Knowledge Forum. A total of 106 student contributions (notes) were analyzed for this study.

Framework and Plan of Analysis

In order to examine the extent to which students engage in computational thinking, we employed the Creative Computational Problem Solving (CCPS) model presented by Chevalier and colleagues (2020) - see figure 1. The CCPS model follows the model presented by Lumsdaine and Lumsdaine (1994) which considers human interactions

with the robot to implement the solution. The model consists of five phases typically completed in order, but transitions between different phases are possible at any time (indicated by the grey lines in Figure 1).

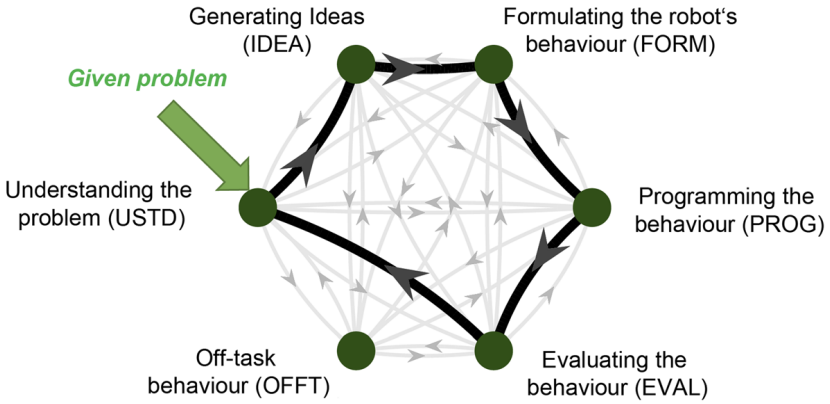

Figure 1. Phases and transitions of the CCPS model (Chevalier et al., 2020)

Table 1 shows the descriptions of each phase according to the original model as well as our interpretations of the model for the purpose of the study along with an example for each phase from our data.

Table 1: CCPS framework and the descriptions of each phase

CCPS Phase	CCPS Description	Our Description	Example from the data
Understanding the problem	Identifying the problem using abstraction decomposition	Discourse around what is required in the task card - understanding the mathematical process involved to solve the problem	*"we also need to make an irregular shape which has a lot of turns"*
Generating ideas	Sketches of robot behavior that would result in the required transformation	Theories/explanations about the expected behavior of the robot and how to successfully complete the task	"*If we taped a dry erase marker to draw a shape on the white board it would not twist but the turns will not be 90 degrees they would be curved"*
Formulating the robot's behavior	Formulating algorithms or step-by-step instructions for rendering the solution	Statements outlining the step by step instructions followed or to be followed	*"Wait: We made it wait 2 seconds when it reached every vertex"*
Programming the behavior	Writing and executing code to modify the robot's behavior	---	---
Evaluating the behavior	Evaluating whether the behavior is an appropriate solution	Statements/explanations about the robot's actual behavior after executing the code.	*"We got the vex to draw a L and then we measured the sides . we were 2 cm off ! on our first try"*
Off-task behavior	Any behavior that does not involve the problem solving process	Reclassified as "Other behavior" - any behavior not classified as one of the other categories, such as asking questions	*"What were the measurements?"*

The first three phases: understanding the problem, generating ideas, and formulating the robot behavior do not involve programming, while the last two phases involve writing and testing of computer code. To verify the CCPS framework, Chevalier et al (2020) captured student videos and analyzed their activity as they worked on their robotics task. As our study involves the analysis of textual data, we attempted to map the different phases to different discourse movements observed in Knowledge Forum notes. As noted in table 1, because of the nature of the data we were unable to code the actual "programming" phase - hence the corresponding cells in the table are empty.

Results

Knowledge Forum notes were analyzed according to the coding scheme described in table 1. Two coders independently coded the data, with an agreement rate of 93%. Discrepancies were discussed and resolved. The results of the coding scheme are shown in Table 2.

Table 2: Results of coding students notes according to CCPS framework

Understanding the problem	Generating ideas	Formulating robots behavior	Programing the behavior	evaluating the behavior	Other behavior
10%	25%	6%	0	22%	37%

As indicated in table 2, no notes were coded as "programming" and only 10% were coded as "understanding the problem". Students did in fact engage in these two phases during the face to face activities which are not captured in the online discussion on Knowledge Forum. Students actively participated in programming activities using a graphical programming environment called "ROBOTC graphical." This programming environment, which includes a graphical natural language editor, allows beginners to use simplified commands such as "Forward," "LineTrack," and "Repeat" loops. Its real-time debugger allows users to run code line-by-line and monitor values on sensors, motors, and encoders in real-time. During their face-to-face activities, students developed codes and uploaded the codes into their robots to execute the tasks.

Moreover, while there are some notes that show students' attempts to understand the problem, students mainly discussed the problems during face to face activities. Figure 2 shows two examples of student work during face-to-face discussions as they attempted to analyze and understand the problem.

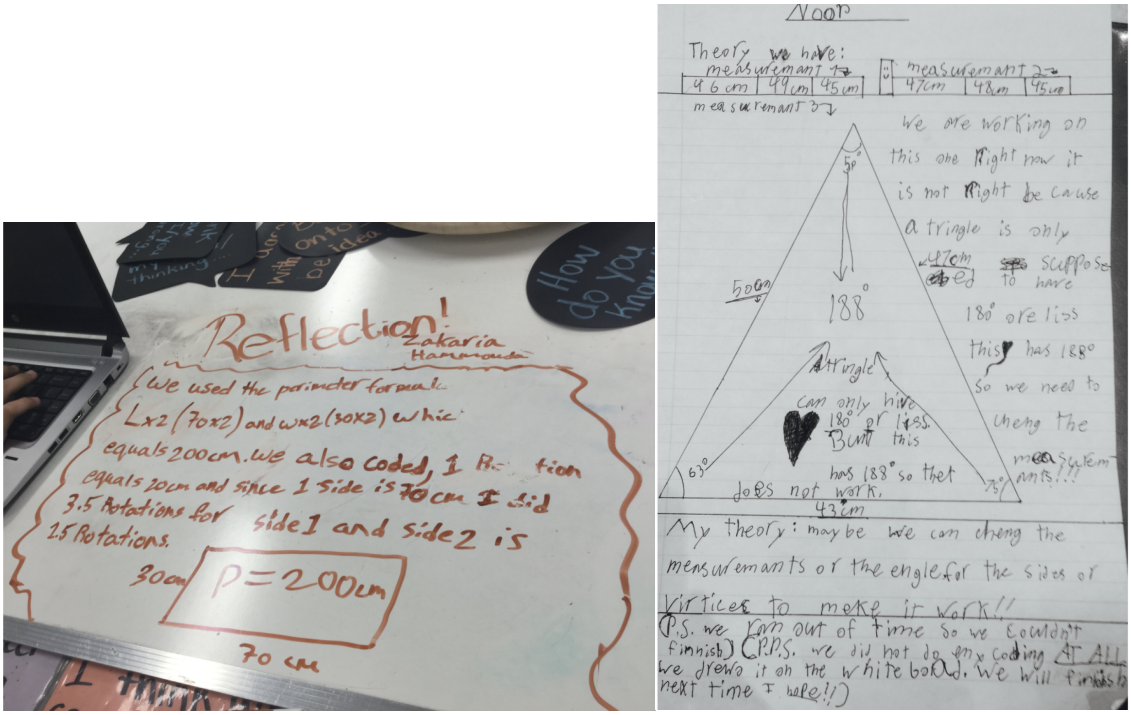

Figure 2. Two examples of student work as they engaged in 'understanding the problem'.

As indicated in table 2, students actively engaged in generating ideas (25%) and evaluating the behavior (22%). These two categories show students' attempts to discuss different ways to tackle the problem and overcome the challenges they faced (generating ideas), and debug their programs to ensure they have a functional code that allows the robot to perform the task accurately (evaluating the behavior).

Table 2 also shows that most students' notes are coded as *other behavior*. In our analysis, we found that there is no written discourse that qualifies as 'off the task behavior' since all contributions were related to the actual task at hand and enabled further engagement in knowledge building discourse. We reclassified this phase as 'other behavior' which simply includes any notes that do not fall under any of the five phases of the original CCPS framework. Further analysis of all notes coded as 'other behavior' showed that 33% were student questions, for example, "Can a triangle be less than 180* or does it have to be 180*?". 60% of the other behavior notes were statements of agreement or disagreement with other students, for example, "I agree With you [student name] because that is what happened." The remaining 7% were coded as 'ambiguous'.

Discussion and Conclusion

Overall, the findings of this case study support and add a social dimension to the computational thinking process. Indeed, one of the educationally significant findings of this study is the willingness of students to take collective responsibility to improve the knowledge of the community, without a need for a teachers' guidance. These results show that students as young as age 10 have the ability to engage in a computational thinking process in a student-centred environment.

The results suggest that students actively engaged in generating diverse ideas– which is essential for advancing both computational thinking and Knowledge Building discourse. Students developed ideas and theories on how to improve their code and overcome other challenges- such as the twisting of the paper when their robot is moving. From Knowledge Building perspective, knowledge advancement depends on the diversity of ideas generated in the community. From a computational thinking perspective, students become computational thinker sand knowledge constructors if they actively engage in generating ideas and theories (ISTE, 2016).

Moreover, the results show that students actively engaged in evaluating their codes/ideas, which is also key to both Knowledge Building and computational thinking. From a Knowledge Building perspective, students should engage in concurrent, transformative assessment of their ideas; such self and community assessments enable knowledge advancements and idea improvement. In this study, students engaged in concurrent and transformative assessment by evaluating the robot's behavior, in order to improve the codes. From a computational thinking perspective, this evaluation step is necessary for debugging and fixing the computer program to achieve the desired outcome.

There are only a few studies (i.e., Khanlari, 2019a, 2020a; Khanlari & Scardamalia, 2019) that explore how knowledge building pedagogy and technology can support educational robotics. The present study contributes further to this area in the literature in addition to the computational thinking literature by examining how engaging students in educational robotics within a knowledge building environment can facilitate the advancements of computational thinking competencies.

One limitation of this study is that the activities (i.e., task cards) were designed by the teacher, instead of giving students the opportunity to work on authentic problems; the problems that the students care about. The reason for this decision was that most of the students had no prior experience in working with/coding a robot. Therefore, the teacher decided to provide opportunities for students to learn more about the educational robot and the coding environment. After completing this task, students were given the opportunity to decide about the projects/tasks that they were interested in.

A number of coding schemes are developed to analyze contributions to a knowledge building community (e.g., Cacciamani et al., 2018a, 2018b). However, there is no coding scheme that is focused on computational thinking from a Knowledge Building perspective. To advance this research we plan to replicate this study by analyzing a richer data set. We also plan to create framework based off the CCPS framework which is more aligned with both computational thinking and Knowledge Building perspectives.

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IDEAS-AT-THE CENTRE & THE VALUE OF COLLABORATIVE KNOWLEDGE BUILDING: Educating Physicians About Palliative Care

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Abstract: The Palliative Care eLearning Program builds on the 10-year success of the End-of-Life Care Distance Education, a continuing professional development program for family physicians offered through the Faculty of Medicine, University of Toronto. Created in 2004 this program has been updated in various versions of Knowledge Forum and has evolved in its approach to collaborative knowledge building, from a focus on belief-mode to design-mode knowledge work. The program was initially implemented to address the lack of formal teaching of palliative care in medical education. The 2008 Romanow Commission Report addressed this gap, additions to the curriculum were made and a formal family medicine specialization was established. These developments had a positive impact on our online continuing professional development program, which enabled a shift toward more design-mode work in KF, allowing more room for emergent ideas and personal practice issues. More recently we have seen another shift in the nature of the discourse, that can be characterized as more deeply reflective, authentic, personally and professionally meaningful and at times, philosophic. It is easy to measure belief-mode knowledge improvement using pre-posttests and demonstrate read/write/build-on and social network activity measures; however, it is difficult to assess and challenging to convey the *value* of this deeper level, more reflective, transformative discourse that is evident in the 2020-2021 online community. Numerous examples are provided in this paper to try to elucidate the *value* of the ideas-at-the-centre and the deeply reflective nature of the collaborative knowledge building discourse, and its promisingness for personal transformation and systems level change.

Introduction

The Palliative Care eLearning (PCeL) Program is a 9-month continuing professional development course designed for Family Physicians and Specialists, offered through the Faculty of Medicine at the University of Toronto. This program is sponsored by the Ontario Ministry of Health and Long-Term Care and was designed by Leila Lax (PhD), a design researcher and Dr. Anita Singh, a palliative care physician. The program has been running since 2004 in various versions of Knowledge Forum (KF). The current iteration is composed of 6 modules that run for approximately 1 month each in KF (Figure 1), followed by a 12-week post-course reflective-action journal.

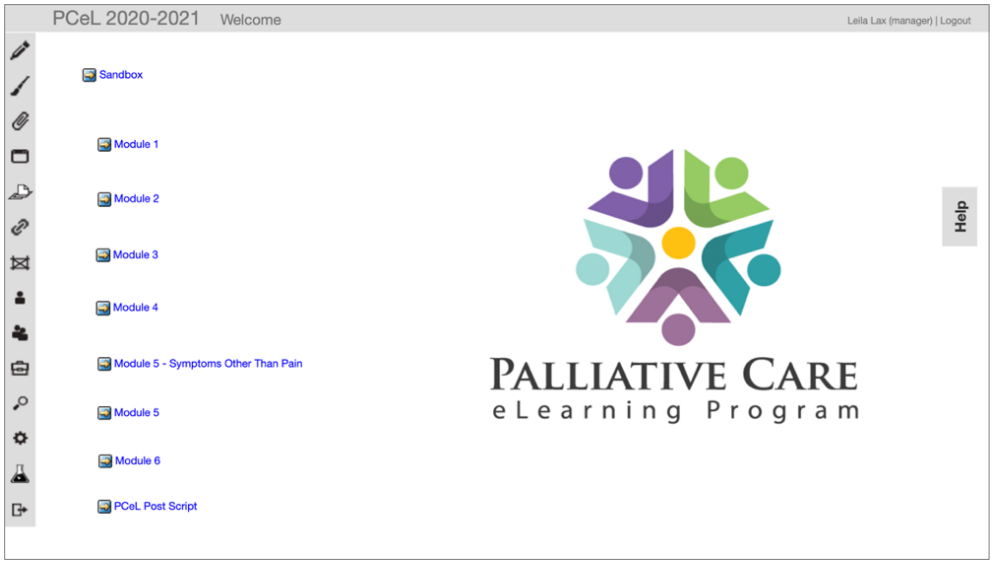

Figure 1. The KF Welcome View.

Each module begins with a clinical scenario that highlights a patient case and various aspects of palliative care, such as pain management, mental health, other symptoms, cardiac treatment, and the last days of life. Although case-based, the knowledge building pedagogic approach in KF is the antithesis of the problem-based learning process typically used in medical education. In the PCeL Program, authentic patient cases are a springboard for discussion of real-world patient issues. Participants are encouraged at the onset to go beyond the case to focus on their related professional practice and real-world concerns, to address the most current issues for higher level authenticity and knowledge translation to practice. The role of the facilitator is different too. In KB in KF the palliative care expert is an active participant and shared leadership is common practice. As you will see in the 2020-2021 discourse notes, the facilitator addresses participants as "colleagues". Typically, 22 participants work in KF and the collaborative knowledge building (cKB) discourse is moderated by 1 or 2 palliative care experts. As you would expect with a group of doctors, the discourse quickly becomes one of shared expertise and ideas (Fig.2).

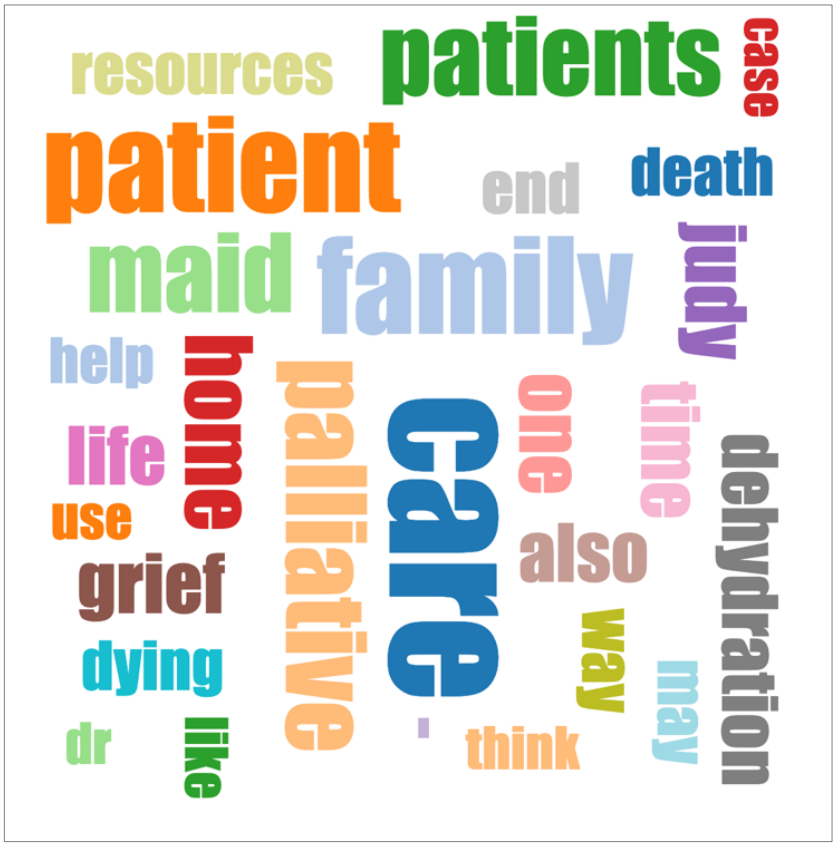

Figure 2. Word cloud of Module 6

Ideas-at-the Centre of Belief and Design Mode Knowledge Building

The KB discourse in the PCeL Program can be characterized as work in both belief and design-modes (Bereiter, 2002; Bereiter & Scardamalia, 2003; Scardamalia & Bereiter, 2014). Work in belief-mode is necessary for understanding of best practices in assessment and patient management. For example, knowing the titration of pain medication from morphine to hydromorphone is essential (Fig. 3) as well as standard practice (Fig. 4). However, what is always more interesting and engaging is the discourse is in design-mode. Such as physicians identifying and problem-solving around issues such as barriers to care for their patients, including psychosocial barriers (Fig. 5). The open-endedness of the cKB approach facilitated by the immediacy of responses and cognitive collaboration in KF (Scardamalia, 2002) leads to numerous emergent, ideas-at-the centre – that is a given.

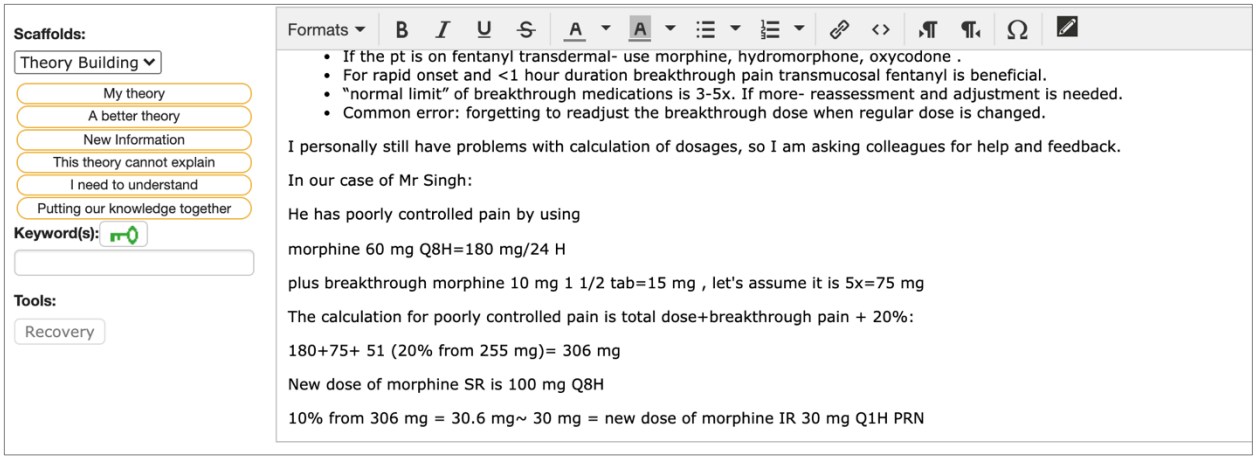

Figure 3. Example of work in belief-mode.

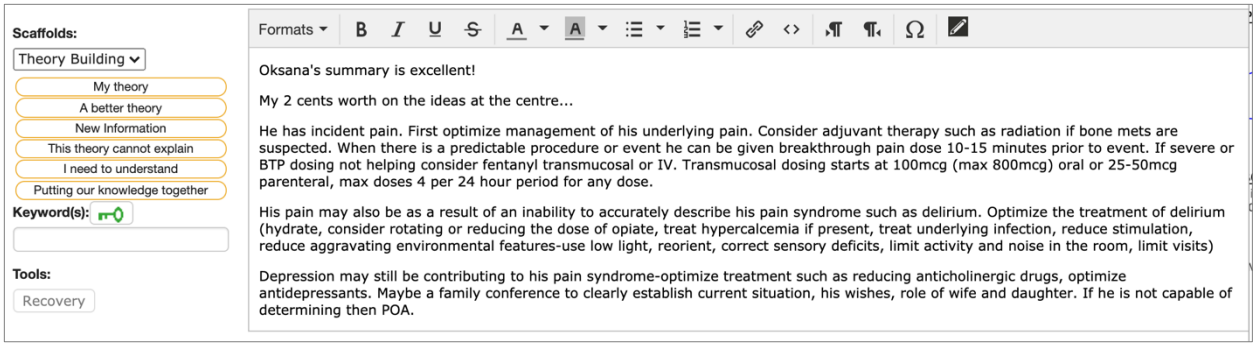

Figure 4. Example of typical solidification of pain assessment and management knowledge.

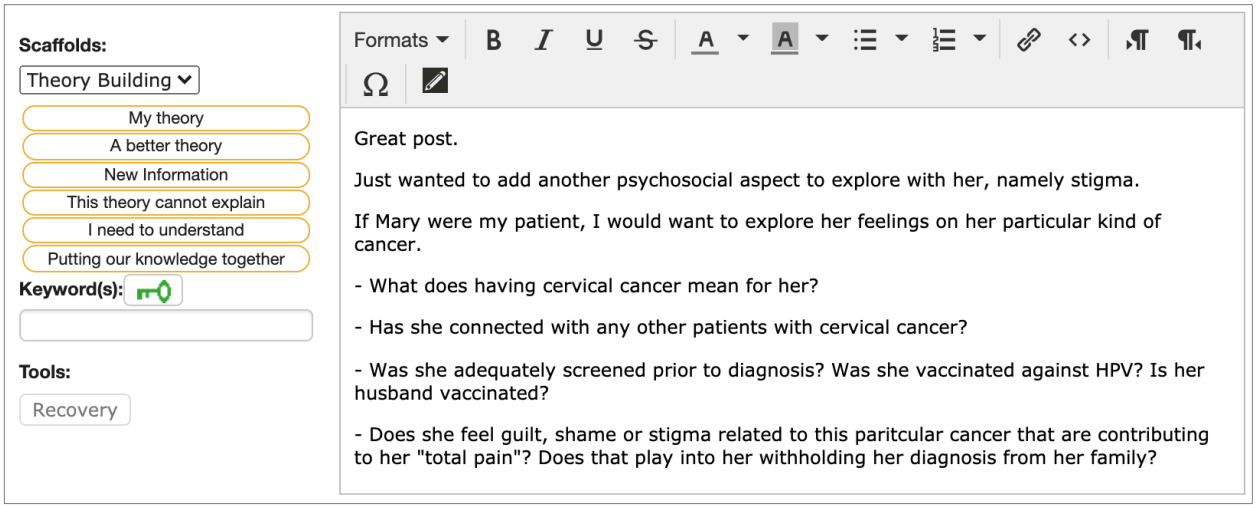

Figure 5. Emergent idea about stigma (build-on notes prompted a discussion on stigma in care).

The Value of Collaborative Knowledge Building

Importantly, what is unique about the PCeL Program and participants cKB in KF database, is that the emergent, ideas-at-the-centre of the discourse that relate to difficult practice issues, are often very personal in nature and sometimes quite philosophical (Fig. 6). A trusted, secure environment of mutual respect between colleagues is event in what

becomes a highly engaged community of knowledge builders. This is unique in a CPD course and goes well beyond knowledge mobilization and the competency-based curriculum. This is the meaningful *value* to professionals in the PCeL Program (Fig. 7). The *value* that participants derive in this course is not just knowledge improvement or new ideas or different perspectives. It is something "other" that one participant described as "therapeutic". It is this deep, personally meaningful, reflective layer, derived from cKB that is unique to this educational experience that ignites change – in the person and in their practice.

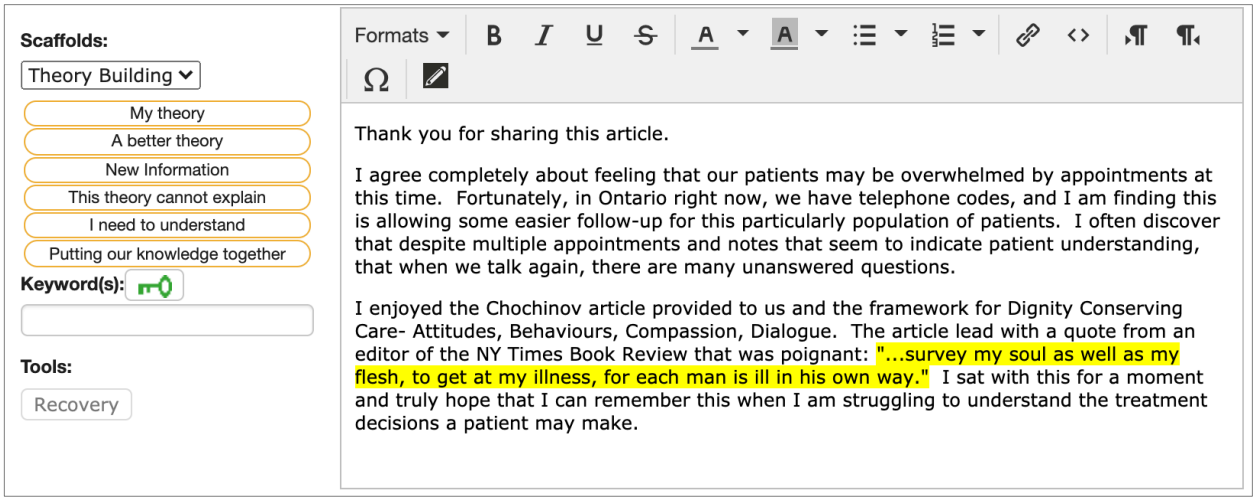

Figure 6. Example of design-mode work.

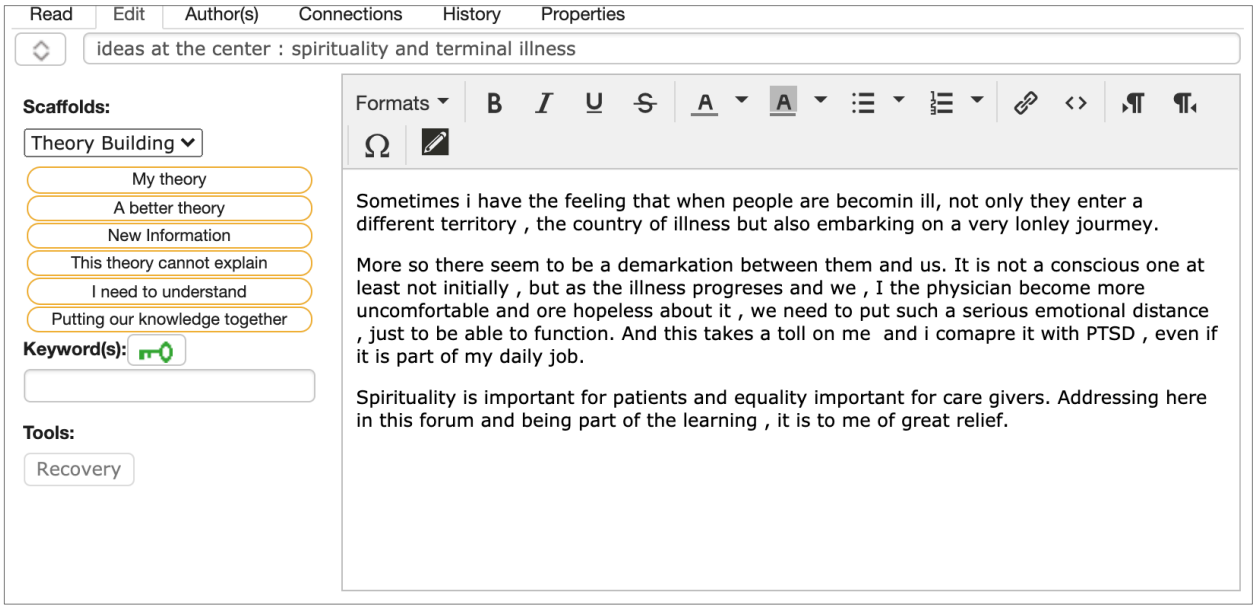

Figure 7. "...this forum and being part of the learning, it is to me a great relief."

This philosophical or therapeutic layer of cKB may be particular to family physicians and to the subject matter of palliative care, that is even more pronounced over this past year during Covid-19. This "other" layer of cKB, valued by participants, is very difficult measure or make tangible or explicit. It is this *value* of cKB that I have found so difficult to convey in my research presentations and publications.

Sure we can measure the worth of cKB by demonstrating typical knowledge improvement on pre/posttests (Lax et al., 2015). But that doesn't capture this essence. We can all agree on the benefits of collaboration versus

individual learning and demonstrate active participation, through build-ons and social network measures (Lax et al., 2016; 2010). But that doesn't capture the essence of the extraordinary layer of "going beyond". Emergent ideas are often amazing realizations. But that too happens on occasion in a classroom. The "ah-ha" moment, as it is called. So what is this "other" in cKB that participants value, that is typically devoid in traditional, individual, competitive learning environments?

Discourse in the Palliative Care KF environment, goes beyond belief-mode and design-mode work with knowledge into, what I will call – for lack of a better term, "meaningful, transformative reflections". This is not about problem-solving as we are familiar with it around World 3 knowledge issues, but something else, that is deeply personal and at times, philosophical. How to billing for a death certificate is one level of understanding around death and dying, required of a physician; on another level are questions about attending a patient's funeral, physician grief, existential distress and how to remember that patient. This information typically does not go in a patient's medical chart, or does it?

When the discourse goes beyond World 3 knowledge and the discussion becomes more reflective and philosophical as we see in the following ideas-at-the-centre about other kinds of care (Fig. 8), communication (Fig. 9), hope (Fig. 10) or about existential distress (Fig.11).

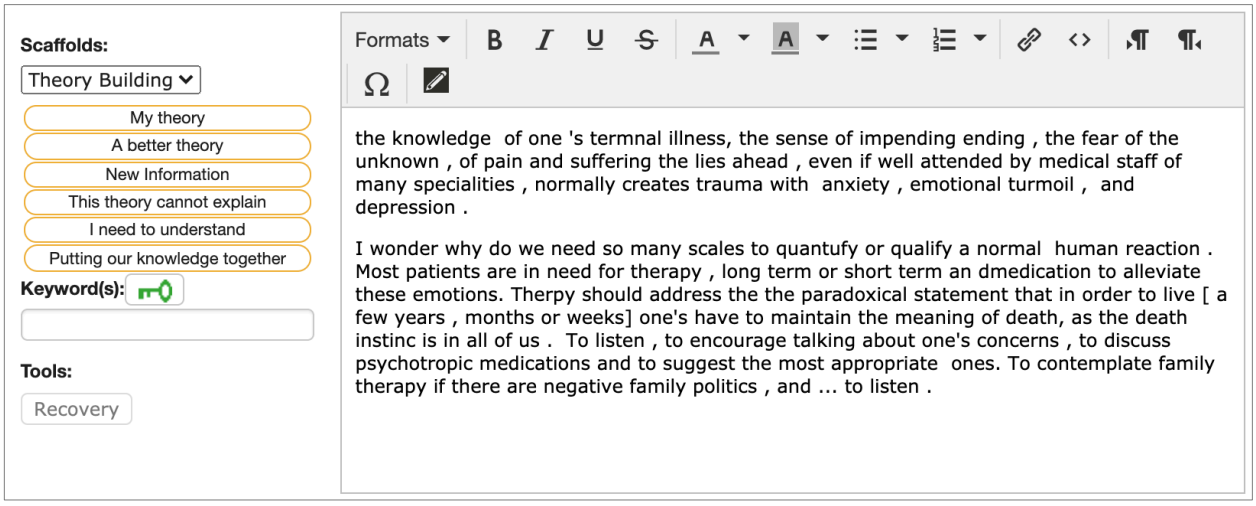

Figure 8. Other kinds of care are elucidated.

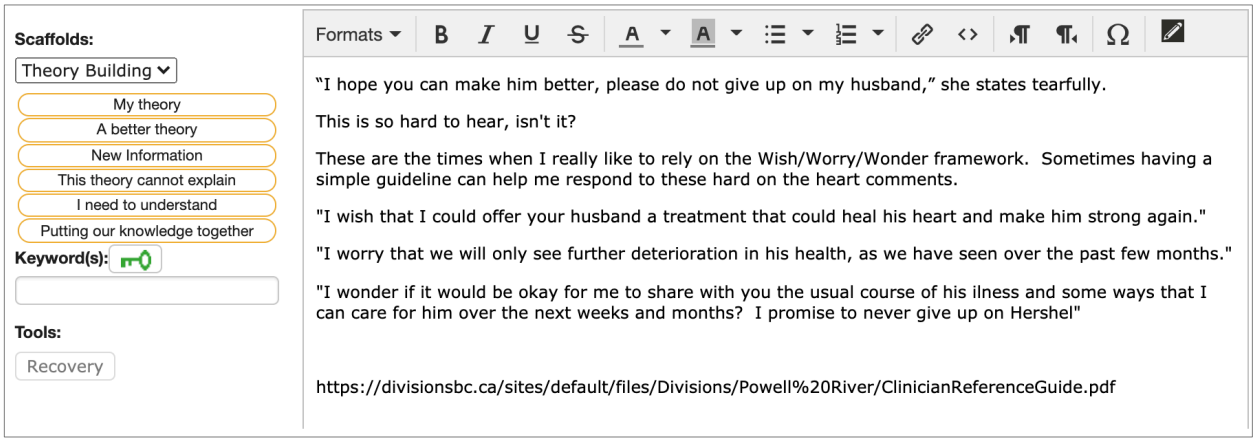

Figure 9. Communication as care – the "wish/worry/wonder" framework.

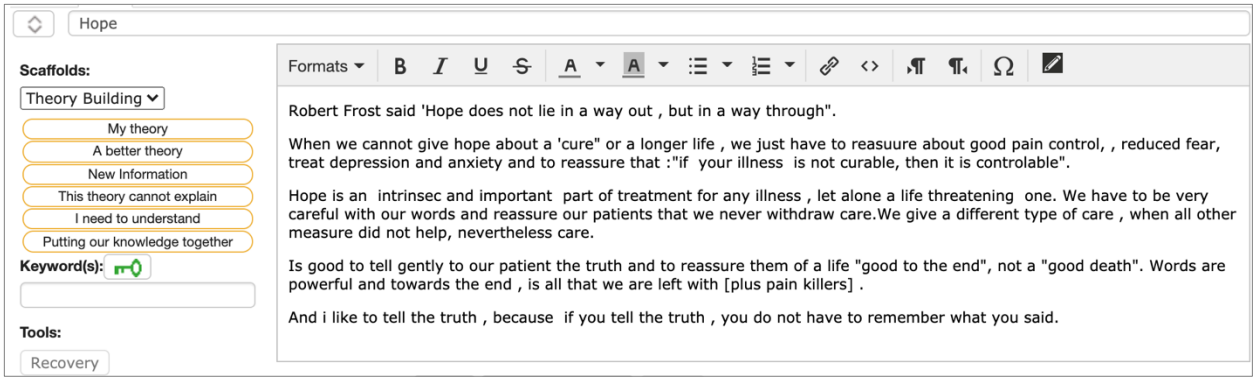

Figure 10. The purpose of "hope".

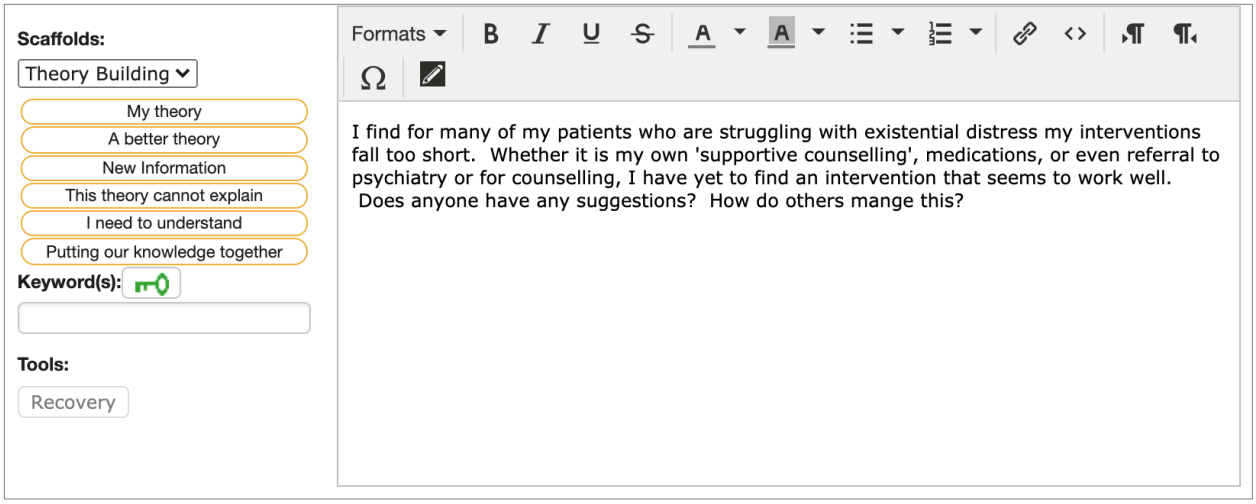

Figure 11. Going beyond traditional learning; this is an example of participant reflective KB around a personal, meaningful, complex issue of care.

New controversial issues are discussed, e.g. psychedelics (Figs. 12 & 13) to treat pain at end-of-life and MAid (Figs. 14 & 15) that exemplifies shared leadership throughout the database. Participants teach the Facilitator and their colleagues.

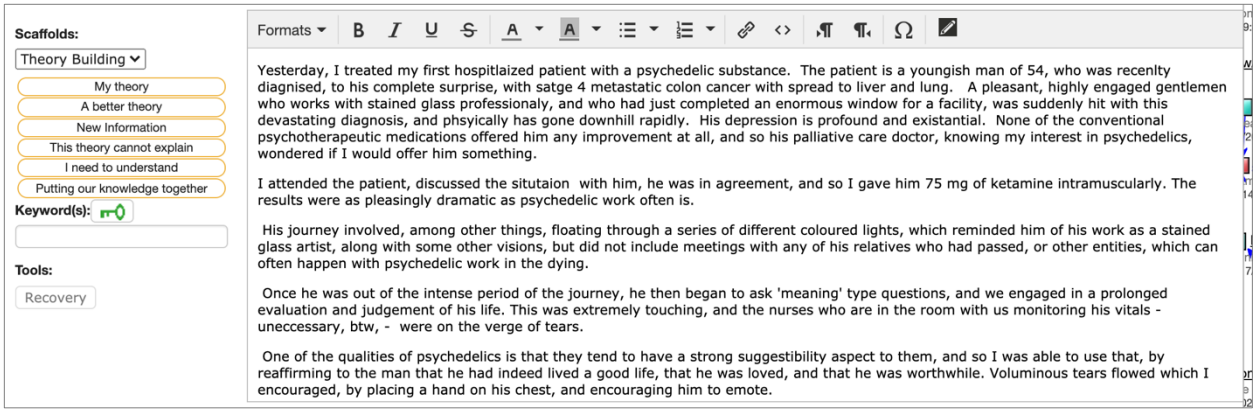

Figure 12. Shared leadership and expertise.

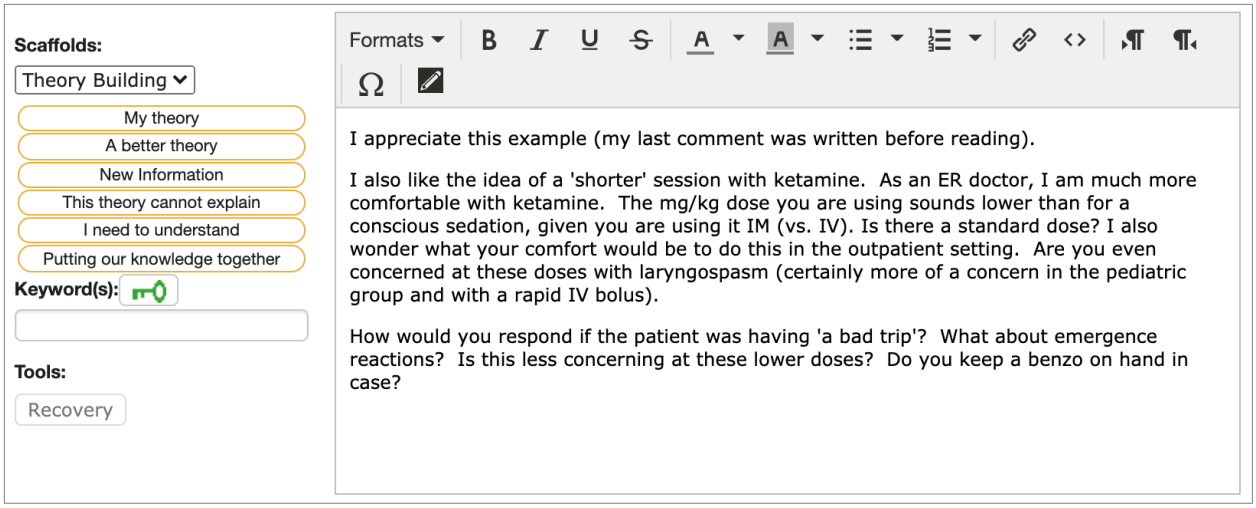

Figure 13. Building-on shared leadership.

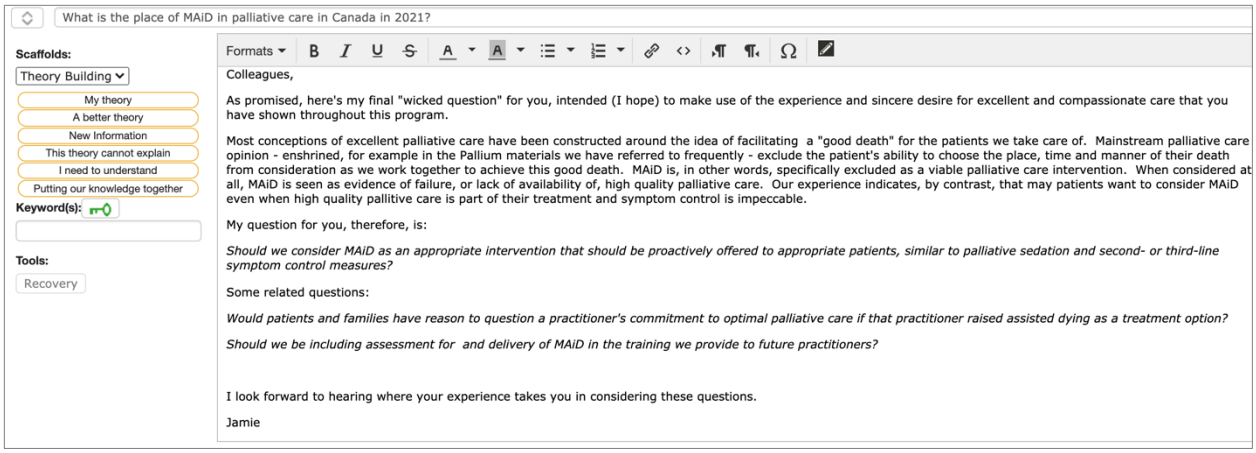

Figure 14. Facilitator prompts cKB on a current issue, MAid.

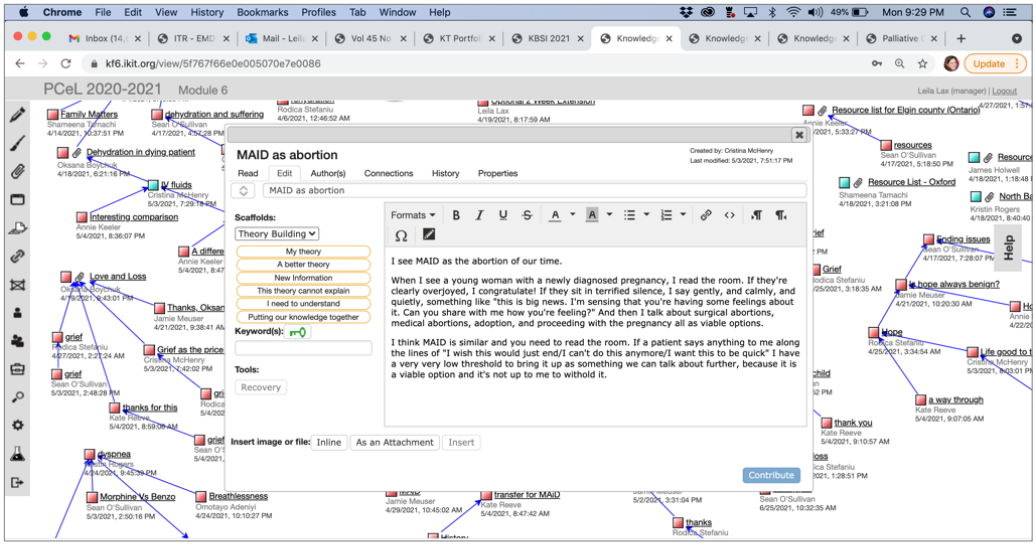

Figure 15. Shared perspectives for new understandings.

When I read the notes in this KF database, it is readily apparent that there is a much deeper layer, more reflective layer being addressed. Yes, it is important to know how to titrate pain meds, but it is also important to know how and when to give a family hope and when not and how to deal with the grief of losing a patient (Fig. 16). This is the tough stuff. This is the stuff that goes "beyond" learning the titration of pain meds, that is essential to the identity, integrity, personal and professional development of a family physician (Fig. 17). Perhaps this the *core* of care that really counts and the core of CPD that really matters, beyond the basic competencies of practice. The cognitive collective responsibility to each other, the openness of cKB in KF enables work at a different depth and breadth than that found in a typical educational environment (Scardamalia, 2002; Chen, 2017). KF provides a unique opportunity for the development a secure cKB community of practitioners that we have found adds tremendous *value* to continual professional development in medical education (Fig. 18).

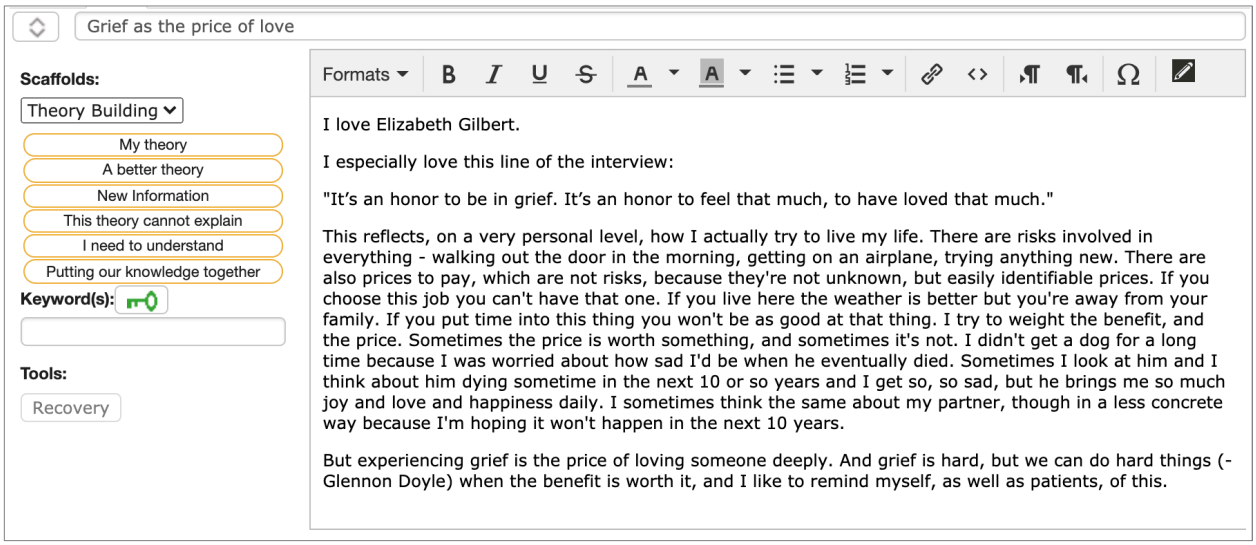

Figure 16. Dealing with personal grief.

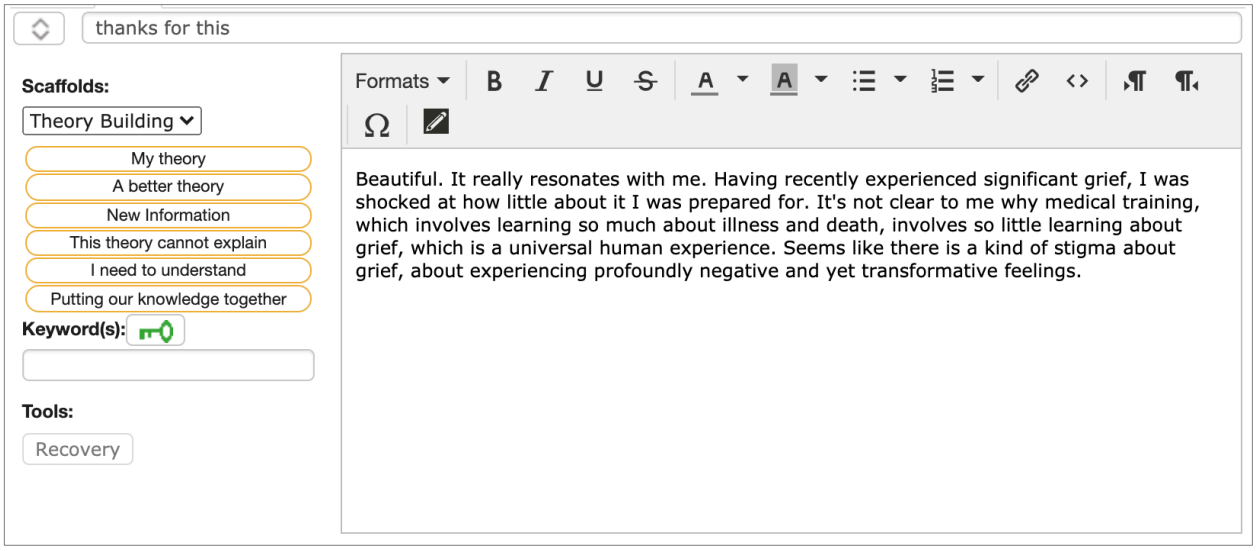

Figure 17. Questioning larger systems issues on medical training.

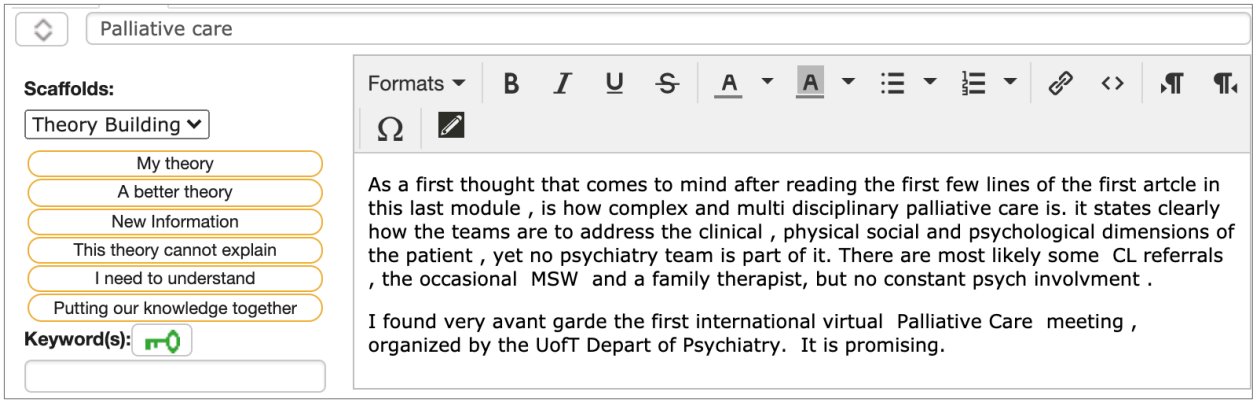

Figure 18. Promisingness of new ideas for improvement in practice, at the personal and systems level.

Conclusion

The 17-year success of this continuing professional development course is its continual evolution through cKB. The democratization of discourse, share leadership, openness, privacy, and authenticity the PCeL Program unique as a CPD course. It is the community of colleagues that create an environment of collaboration and trust and the supportive, creative nature of KB in KF, where private knowledge can made public for individual and collective advancement and well-being (Figs. 19 & 20). The *reflective, transformative value of cKB*, goes beyond learning the facts of science and medicine; it is not an educational objective listed on Bloom's Taxonomy, and is not part of traditional palliative care curricular competencies. It is difficult to measure *value* and hard to explicate. But it is tacit. Perhaps the best way for the *value of cKB* to be known, is for it to be experienced.

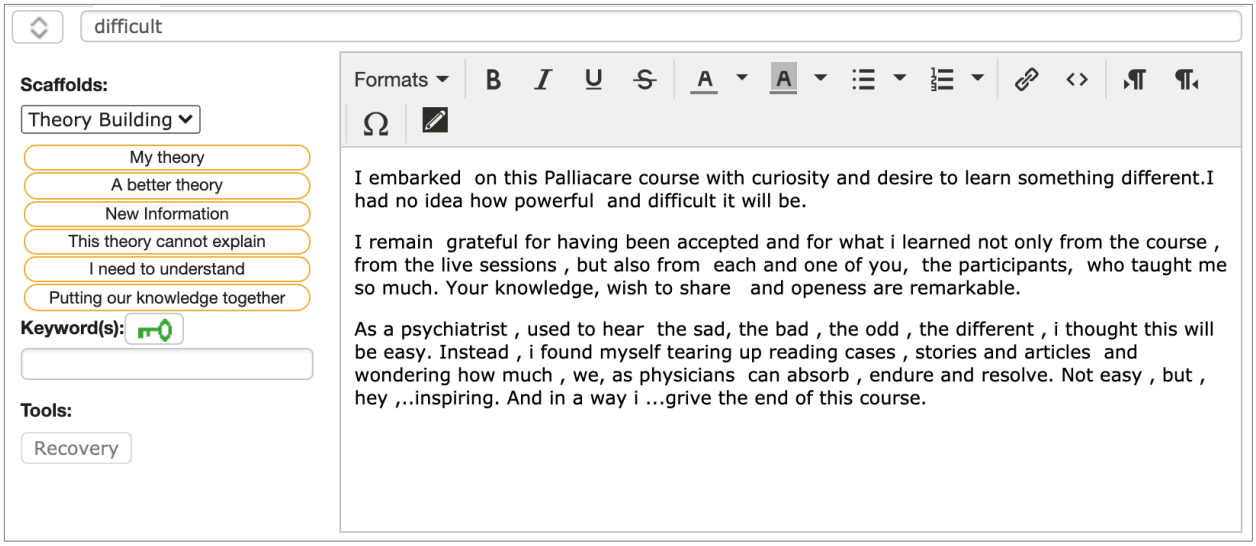

Figure 19. Value of collaborative knowledge building (participant's note).

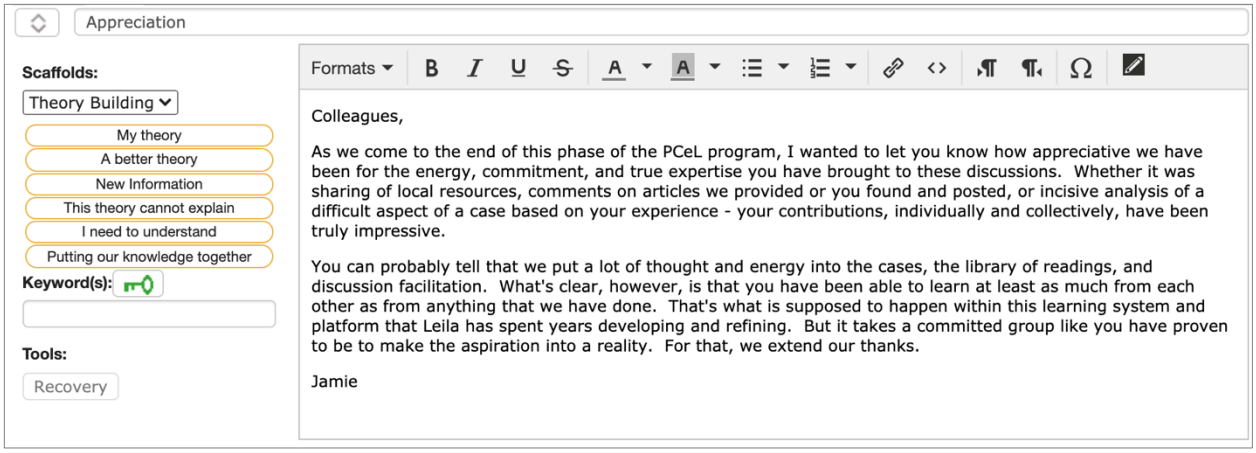

Figure 20. Facilitator's note on collaborative knowledge building.

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Redesigning Curriculum to Support Knowledge Building Learning Analytics

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Abstract: This study examined the use of Curriculum-idea Analytics in a Grade 9 History class. The Curriculum-idea Analytics (CiA) works by comparing the semantics of (i) a set of cross- grades curricula specially mapped for big ideas and (ii) text from students' Knowledge Forum discourse. Specifically, in this case, the CiA is adopted by a teacher to support students' reflection. Thepaper investigates students' perception and understanding of wordcloud and CiA visuals and examines how these visuals influence their collaboration perspectives. Students' contributions on Knowledge Forum provide evidence that students from a knowledge building class can view terms presented in the curriculum cloud as potential ideas to be explored in their knowledge building process. This paper also discusses the transformative role of curriculum-based learning analytics in classroom practice, from scripted resources to a curriculum-idea-interaction.

Introduction

Knowledge building (KB) focuses on the production and continual improvement of ideas of value to a community (Scardamalia & Bereiter, 2003). In a knowledge building classroom, teachers adopt a principle-based approach to support students in an idea-improvement process to advance community knowledge (Scardamalia, 2002). While teachers value the benefits of knowledge building capacities, a common struggle is in reconciling the tensionbetween the divergent nature of KB approaches and the obligations to "cover" the curriculum to prepare students for summative examination. Scripted syllabus in curriculum documents is often not aligned with the generative nature ofKB approaches that value idea diversity and community contribution. As Maton (2009) puts it, "curriculum can constrain knowledge-building by anchoring meaning within its context of acquisition. The basis for this potential is in a mismatch between their aims of enabling students to learn higher-order principles and their curricular means that focus on knowers' dispositions rather than articulating principles of knowledge" (p. 43). This mismatch poses problems for teachers in implementing KB pedagogy, and it is not surprising to find teachers compromising rather than wholly embracing the knowledge building process. This study attempts to encourage teachers and studentsto take on a broader view of ideas by leveraging the "big ideas" of the curriculum as a constructive resource to supportreflective practices in a KB classroom. Aligning with Chen and Zhang's (2016) notion of agency-driven, choice-basedanalytics to support higher-order competencies, CiA is programmed to generate visualizations called "curriculumclouds" which mapped in keywords from student discussions benchmarked with the "big ideas" of the curriculum. In doing so, we hope students can be supported to choose the ideas they want to build on and explore further. This paper reports on students' perception and use of curriculum clouds in a history topic discussion.

Context

In Singapore, we see a concerted effort to develop 21st Century competencies (Ministry of Education Singapore, 2021). However, the deep-rooted examination-driven culture, which values performance at high-stakes examinations (Lam et al., 2013), has a much stronger influence on the ground. A set of centralized curricula defined a guideline on the overarching knowledge structure and content to help teachers prepare students for the examinations. The same centralized curriculum also explains, to a great extent, disciplinary thinking, the disposition, and the skills required for each subject. The curriculum documents served as a resource to ensure even baseline practice on teaching and learning. These documents are meant to guide teachers in their teaching and learning practice. However, many teachers treat these curriculum documents as something that needs to be adhered to, like a script. These teachers tend to forego students' questions and ideas arising from their curiosity if the questions/ideas do not directly map onto the instructional objectives defined in the curriculum script. Many studies have reported curriculum as one of the top hindrances in innovative pedagogy. Despite such a negative take on curriculum, we saw the opportunity to reshape the role of curriculum in class so that teachers can learn to appreciate students' ideas and questions beyond the curriculum. Here, we propose a coordinated redesign effort of curriculum and pedagogy to support idea-centric practice as an innovative pedagogy.

Literature review

Knowledge building focuses on the production and continual improvement of ideas of value to a community (Scardamalia & Bereiter, 2003). The essence of a knowledge building classroom is to support students in the idea improvement process and work in a principle-based approach (Scardamalia, 2002). In a KB classroom, teachers focus less on the list of activities to go through in a class but more on the ongoing discussion, students' voices, ideas, and

questions. Reflecting on ways to move forward would make students work harder and learn better. This is a tall order for any teacher, and the challenge is to find the proper support for these teachers to ease into working with students' ideas.

Agency over curriculum and learning.

Scardamalia and Bereiter, in their seminal paper in 1999, painted this knowledge-building scenario that involves curriculum in one of their studies. They used a KF database posted with the mandated curriculum objectives related to the students' study. The students linked their work to appropriate objectives and commented on the relationships, identifying what they saw as additional objectives worth specifying. Although there were no two-way interaction-to curriculum documents, the experiment demonstrated that "students could make contributions to curriculumplanning as well as provide rich data for anyone investigating curriculum problems" (p. 14). From this example, weunderstand that the key in students' involvement in curriculum matters lies in the level of agency over the curriculum and, more importantly, their learning.

Learning Analytics as Embedded, Concurrent & Transformative Assessment.

Over the years, the research community has made many creative designs of learning analytics (LA) to support idea-centric work in KB classrooms. In the early years of Knowledge Forum, a suite of analytic toolkits (ATK) was already embedded with Knowledge Forum to support students' reflections on their KB activity. ATK reveals the collaborative effort and their social network by analyzing the use of different features of the Knowledge Forum, such as build-on notes, keywords, and scaffolds (Burtis, 1998). KBDex (Oshima, Oshima, & Matsuzawa, 2012) was subsequently developed as a research tool to reveal the pivotal point in the students' discourse that facilitated this social knowledge advancement through various centrality measures. Further work was developed using KBDex to evaluate learning processes (Ma, Matsuzawa, Chen, & Scardamalia, 2016; Matsuzawa, Oshima, Oshima, & Sakai, 2012; Resendes, Scardamalia, Bereiter, Chen, & Halewood, 2015). The most recent one uses KBDex to measure rotational leadership (Ma et al., 2016) to inform the democratization of the KB process.

Later, there was increasing effort to engage teachers in Vocabulary Analyzer, a Social Network Tool, and a Semantic Overlap Tool for principle-based Knowledge Building (Hong, Scardamalia, Messina & Teo 2015). This includes using temporality measures from analytics to inform knowledge building discourse (Teo, Chan& Ng, 2018). Further development has seen a strong move towards student-facing analytics for feedback on the community's progress and further evaluation of how to improve ideas. One of the interesting developments of this student-facing LA is seen in the work of "Idea-Friend Maps", in which complex design representations of KBDex, integrated with relevant social configurations, are shown to students to improve collective inquiry. Higher levels of conceptual understanding, higher levels of social participation, and more advanced collective knowledge (Feng, van Aalst & Chan, 2019; 2020) were seen happening in classes with young children.

Design Rationale

There is a need to shift students' conceptions of curriculum and learn to embrace idea progression & improvement as an important part of learning (Afandi & Baildon, 2015). A recent study by Lin, Tan, Lee and Tsai (2017) identified Singaporean students having a higher tendency to view assessments and curriculum as opportunities to improve learning. This reflects a higher readiness level to accept curriculum information as "ideas to explore" instead of a "checklist of learning outcomes" and presents an opportunity to infuse curriculum information into teaching and learning practices.

Existing KB studies have shown that students' involvement in the curriculum reaps positive benefits (Zhu, Raman, Xing & Slotta, 2021). This study uses CiA as intermediary analytics to support idea-centric pedagogy (Ong, Teo, Tan & Kim, 2020; Teo, Ong & Lee, 2021). This study analyses students' perspectives on Word Cloud and CiA in guiding their KB progress.

This study seeks to contribute to the research field of KB by revealing students' impressions of curriculum-based learning analytics tools and understand students' perception of curriculum and learning with the introduction of CiA and Word Cloud as reflection tools. The qualitative inquiry allows students to disclose how they reflect on their learning, perceive the data provided and reflect on their KB behaviour. This study is guided by two research questions: (1) How do students perceive Word Cloud and Curriculum-Cloud? (2) How does Curriculum-idea-Analytics affect students' Learning Activity?

The Curriculum-idea Analytics (CiA) is designed to support students in exploring the "big ideas" of the curriculum and thus be able to view the curriculum as one of the authoritative sources in their KB process. "Big-ideas-

Curriculum" here represents a set of curricula that is connected across disciplinary or interdisciplinary subject content and building towards a few unifying ideas. For example, we mapped the national History curricula on War were mapped across grades 7 to 12 in two layers: (i) First-level unifying themes: causes, impact, context, reasons ofwar; (ii) Second-level unifying themes: superpowers, policy, ideology, tensions.

Method

Twenty four grade 9 history students participated in this study. The class was taught by an experienced KB teacher withseven years of Knowledge Building experience.

Students engaged in a one-week online discourse on "Why did the world descend into a global war from 1939-1945?"on Knowledge Forum. At the end of the 1-week online discourse, three sets of Word Cloud and CiA visuals based on different grade levels (grade 7 - 8, grade 9 - 10 and grade 11 - 12) were generated and posted on KF. The teacher tasked the students to examine the word clouds and CiA visuals and reflect on the question, "as a history student, which is more useful for you concerning your understanding of World War 2?".

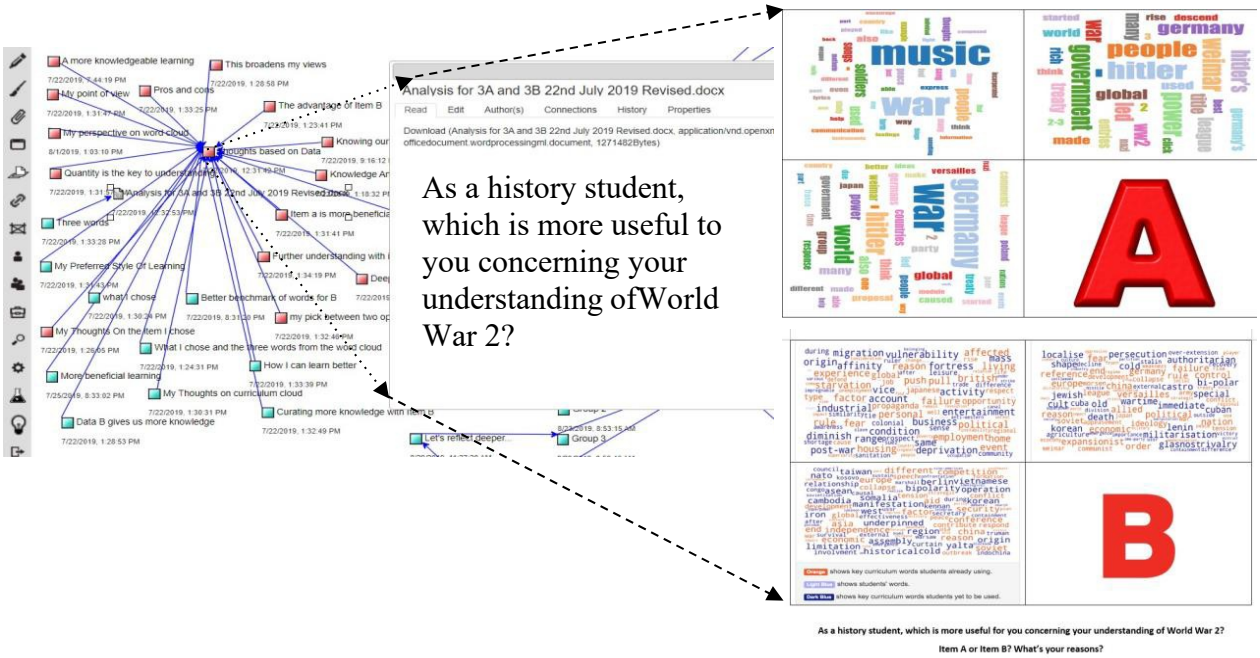

Figure 1. Knowledge Forum discussion and reflection prompt on Word Cloud and Curriculum-idea Analytics.

Students were asked to prepare and post a reflection note on KF to evaluate their perception of the two learning analytics provided. In their contribution, students were asked to indicate their LA of preference. Students were also required to explain why the LA of choice best supported their learning. The reflection notes were analyzed based on a grounded approach.

Results

Students' perception of Word Cloud and Curriculum-idea Analytics.

Data: we analyzed 34 reflection notes on KF posted by all students in the class. We found the following:

1. Generally, students viewed the Word Cloud as the less useful analytic tool. Twenty-one students preferred CiA visuals, while three preferred the Word Clouds. The students shared that the Word Cloud summarised the ideas discussed in the community while the CiA presented new terms with potential for furtherprogress.
2. For those who chose to talk about CiA, it is interesting to note their reason for this preference. Students held onto two ideas about curriculum as analyzed from these reflection notes, (i) they view curriculum as a manual in helping their knowledge building and (ii) they view curriculum as useful ideas for their knowledge building endeavor.
    - *Curriculum as Manual.* Some students viewed the CiA as a baseline or checklist to gauge their progress towards completing learning outcomes stated in the curriculum.

"Item B (CiA) is more useful for understanding World War II as it shows us how much we have understood and that there is more to understand. (S5)"

- *Curriculum as Ideas.* The majority of the students viewed the new terms in the CiA as uncharted areasthat could be potentially explored to learn new perspectives.

"Item B (CiA) shows what we are lacking as a class in terms of knowledge of the war. From there, we can improve and expand our thinking by using the words we didn't use previously. Also, there are more cheem (difficult) words for us to search on and from there, we could go in deeper and possibly create their own theory" (S16)

In this group of students who see curriculum as ideas, students mentioned that the new terms provided alternative ways to convey ideas previously discussed, and they saw it as a tool to help expand their vocabulary:

"(CiA) points out those words that we frequently use and those words that we don't usually use... Therefore, the next time I can get to think more in detail about the words that I don't use often and also get to more new words in detail to help me have a better understanding of World War II." (S8)

3. 3 out of 24 students indicated their preference for the Word Cloud in their reflection notes. One reason raised was that the Word Cloud provides a summary of the terms used by the community. A student shared her preference to examine her community's ideas:

"...the word cloud is more useful, it shows what words are used by the majority hence showing the more important words as compared to the Curriculum Cloud… (S2)"

The other reason was the familiarity of the terms presented in the Word Cloud. One student wrote:

"... I understand the words in the word cloud better as I have learnt it before, and I used them in my entries too. However, the curriculum cloud shows some words I don't understand and I won't be able to use them in my response... (S1)"

Effects of Curriculum-idea Analytics on Student Learning Activity.

Students' use of CiA is characterized by progressive action towards a deeper analysis of their ideas. Reflection notes were analyzed to characterize the responses of students as they interact with the CiA into four types of responses: (i) Inaction; (ii) Action to complete syllabus; (iii) Action to improve ideas and (iv) Action for deeper analysis.

Table 1: Types of student responses after interacting with CiA.

Types of responses	Description	Example
Inaction	• Passive approach to CiA. • Students were not inclined to understand the new terms presented. • These students also indicated preferences for the Word Cloud.	"… CiA shows some words I don't understand, and I won't be able to use them in my response as I am unsure of the definitions. As a history student, it is important that I understand the topic so that I can write my entry easily..." (S1)
Action to complete syllabus	• Students perceived the *Curriculum as Manual*. • Students used the CiA to gauge the extent of completion of the subject's curriculum.	"Item B (CiA) is our ideas from lower secondary to the current one and also A-level whereby there are more ideas… CiA is based on what we have learnt and what we will learn." (S13)
Action to improve ideas	• Students perceived the *Curriculum as Ideas*. • Students researched new terms in the CiA to broaden their views and deepen their understanding. • Some students identified less used terms and indicated interest	"… CiA shows words that may or may not be known to students and that causes us to research more... we start to see a connection between all the words and events and sometimes even unknown events that could have been the cause of how history is today which would open up a whole new perspective on how we as students see things... " (S4)

	to discuss these terms at a deeper level.	"… the next time I can get to think more in detail about the words that I don't use often..." (S18)
Action with deeper analysis	• Students perceived the *Curriculum as Ideas*. • Students presented more sophisticated interpretations of CiA that transcended the aim of exploring new ideas to broaden perspectives. • These students categorized the keywords and critically analyzed the terms in the CiA to derive insights into the content and practice.	"We can Google and research the words that are provided in item B (CiA) to form fragments of the events that were related to World War II. Simple words like Japanese, British, Germany, Jewish, Fear and political shows us the rough idea of who is involved in World War II, what some of the feelings were felt within the people who went through it and some factors that had some effect on the outcome of the war. Some advanced words we have not used like glasnost and NATO can give us events or weapons that either were involved or were being made due to the war's influence." (S10) "… I can get new words or ideas to support my idea on understanding World War II better with new in-depth information from the JC level to use it in my answers. I can also revise certain points and words from the lower secondary portion and use them in understanding World War II better which can help me to improve my sources and explanations in my answers." (S11)

Discussion

This paper highlights the potential of CiA to support students to develop a constructive view of the curriculum. Compared with Word Cloud, we found that students were able to perceive CiA visuals as a tool for ideas-building and identified new learning opportunities presented in the visuals. Specifically, students' reflection notes using CiA revealed that they perceived *Curriculum as Ideas* where they recognized potential opportunities for exploration and deepeningof understanding. In addition, our findings revealed that the students' actions towards idea improvement appeared to bealigned with their perceptions of CiA. Students who perceived the *Curriculum as Manual* used the CiA to gauge the extent of subject knowledge completion. In contrast, students who perceived *Curriculum as Ideas* took on a more profound analysis of their ideas. These students demonstrated a deeper appreciation for CiA as a scaffold for ideas building. This finding supports our argument that students see possibilities for more constructive engagement with curriculum ideas when we do not impose curriculum as a fixed script.

However, the Word Cloud appears useful to help students appreciate and increase effort towards collective work. Of the three students who preferred the Word Cloud, one reflected a deeper understanding of the Word Cloud and its importance for reviewing community contributions and what was important to the community. This point highlights students' appreciation of the Word Cloud to support the collective effort and how they saw possibilities to develop collaborative and knowledge building dispositions. However, we noted that such visuals could at times constrain students' interpretation of their ideas. For instance, a student expressed that the Word Cloud "limits us to only know the words that majority uses". This constraint reflects a deeper conceptual issue on analytics regarding the connection between the vocabulary of words and student ideas which poses a problem when we employ text-mining mechanisms to support complex KB processes. This study shows that using different word clouds may be one feasible approach to help students appreciate their ideas within the KB processes. This approach further allows us to optimize the affordance of learning analytics to bring about knowledge building as Word Cloud and CiA can serve different purposes to help students understand their collective ideas in the KF discussions.

Conclusion

In this paper, we attempt to explore students' perception and understanding of the CiA and how it influences students' perspectives of collaboration. Central to our argument is that students can see possibilities for more constructive

engagement with the curriculum when we do not impose curriculum as a fixed script. Our findings suggest that CiA provided students with opportunities for *Curriculum as Ideas*. Students who viewed CiA constructively with a learning frame of mind used curriculum terms to explore connections and deepen understanding of historical developments across grades (comparing lower secondary, upper secondary and Junior College curriculum) rather than interpreting those terms as set criteria for examinations. While our findings provide a proof of concept, the sample size of participants is small thus, our findings cannot be generalized at this moment. More research is needed to establish the usefulness of CiA and Word Cloud in KB classrooms. Finally, we hope that this work will generate insights to drive more attention and efforts to redesign curriculum for knowledge building.

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Engaging Students in Real-World Problems of Sustainable Living: A Case Study of a Knowledge Building Design Studio

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Abstract: Sustainability education is drawing attention from educators worldwide. This paper examines a student Knowledge Building Design Studio (sKBDS) as a platform for sustainability education during the COVID-19 pandemic lockdown period. The sKBDS was a two-day virtual event that connected thirty students from different schools between ten to fifteen years. The complex nature of sustainability education requires a holistic and integrated approach, which motivates the core design consideration of the design studio. This paper outlines the idea-centric design of sKBDS that aims to foster a knowledge building community of students with scientists and researchers. The goal of this community was to advance the understanding of real-world issues on sustainability collectively. We collected data from students' synchronous and asynchronous discussions and analyzed the diversity and novelty of ideas generated by the students during the sKBDS. We discuss the potential of scaling such an effort for sustainability education.

Introduction

Sustainability education provides opportunities for students to understand complex and critical issues that connect environmental, social and economic problems (Huckle & Sterling, 1996; Orr, 1996). Such education programs often aim to shape how our young learners think about the future and ways to achieve an improved quality of life. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) sets out various sustainable goals such as zero hunger, affordable and clean energy or sustainable cities and communities to support such education efforts (UNESCO, 2020). Sustainability education endeavours to develop in our students the knowledge and skills needed to understand critical global issues, which empowers them to address environmental and global challenges. Therefore, it is important to push for the scaling up of such programs in schools.

Due to the recent COVID-19 pandemic, schools had to quickly modify their teaching methods and adapt to the new normal of online learning. The means and tools to conduct sustainability education also changed with the mandated reduction of field trips and community engagement (Assaf & Gan, 2021), which tend to be the main activities in many sustainability education programs. Thus, we see a need to explore ways to leverage technology for the meaningful implementation of sustainability education during this pandemic time. For this reason, we adopted KB pedagogy and technology to redesign sustainability education for home-based learning caused by the pandemic lockdown and social measures restriction in classrooms. Knowledge Building (KB) offers a feasible way to support sustainability education through online community engagement. KB pedagogy supports diverse ideas and collective discourse to advance the community's knowledge of the problem at hand. An essential tool for knowledge building is the Knowledge Forum, an online environment that supports asynchronous and synchronous knowledge-building discourse. Integrating KB pedagogy and technology into our design, we conducted a virtual student Knowledge Building Design Studio (sKBDS) that supports students to explore sustainability issues they care about and interact with expert communities to solve sustainability problems.

This study aims to understand how sKBDS idea-centric design supports students in the creative exploration of sustainability. We first introduce our idea-centric design of sKBDS, followed by our analysis of the diversity and novelty of the ideas generated by the students from Knowledge Forum discussions.

Literature review

Real-world sustainability issues are often wicked problems. It requires critical thinking about ethical issues, projecting the long-term effects, challenging the status quo, and exploring the necessary changes. It is, therefore, necessary for students to consider sustainability issues as real and impending issues and not as textbook problems. Opportunities to engage students in authentic, sustainable thinking in daily classroom discussions are scarce as these broad topics often do not map well with the syllabus. Schools may have sustainability education programs through a special project (such as Applied Learning Program) or an extra-curricular activity (such as a green club). There are also many environment camps outside schools focusing on environmental and sustainability issues. These trends show that sustainability education is fast gaining traction as an important interdisciplinary area (McFarlane & Ogazon, 2011).

Moreover, studies have also consistently revealed that students care about the environment and often contribute useful ideas when given opportunities to discuss these environmental issues. Sustainability awareness is increasing among young people (Moore, 2005) and this awareness is related to environmental practice (Cruz & Tantengco, 2017; Marpa, Juele & Hiyas, 2016). For example, Greta Thunberg's passionate take on environmental issues has become a global phenomenon that has increased students' awareness leading to worldwide movements for climate change. In recent years, we observed many students and young entrepreneurs pushing for sustainable living and development. However, the bigger question is whether these single-engagement efforts suffice to raise students' awareness of environmental issues and motivate them to act. Yet these trends show that

From our review on camps exploring sustainability issues, we found two common features : (i) these camps often include activities in the natural environment to develop students' awareness and knowledge of the natural environment (Cheeseman & Wright, 2019). (ii) these camps encourage an active action-taking stance on environmental problems (Dresner & Gill, 1994; Samperiz & Herrero, 2018). However, our scan also revealed a lack of an idea-centric approach, i.e., the topics are usually pre-identified. The facilitators lead students to explore specific environmental issues. There tends to be less focus on understanding students' diverse interests and genuine take on the topic (Cheeseman & Wright, 2019). Therefore, although students show more awareness of environmental issues and changes in sustainability behaviours, their lack of opportunities to generate and explore diverse and authentic problems on sustainability presents an opportune area for research and design. This gap fueled a search for an idea-centric approach (Hong et al, 2019; Lee & Tan, 2018) for sustainability programs. In addition, real-world sustainability and developmental issues are pervasive challenges in the modern world, and these issues will evolve. It is pertinent to generate new ideas as the discourse on sustainability and development continues (Sternberg & Lubart, 1999, Douglas & Dean, 2006). Therefore, a meaningful education program should nurture creative minds and novel ideas to tackle these ever-evolving challenges. Yuan et al. proposed a novelty analytic framework to understand the quality of newness in students' discourse (Yuan, 2021) which will provide a lens to understand the quality of students' ideas and questions generated in educational programs and activities on sustainability and developmental problems.

KB environments have been tested in pre-school, primary and secondary school classrooms. Students show capabilities in deepening and sustaining their inquiry of real-world problems to advance their individual and collective understanding (Hong et al, 2014; So et al, 2010; Scardamalia & Bereiter, 2003). In KB, students engage in solving real problems as a true community of learners rather than depending on teachers for knowledge and assessment. Students work together to improve ideas and they see idea improvement as

the goal rather than a fixed answer or solution. The design of a KB environment is guided by 12 KB principles (Scardamalia, 2002). These principles work together to create a vibrant community of learners who can demonstrate collective cognitive responsibility to bring about innovative ideas for knowledge advancement. This study proposes a sustainability design studio that leverages a KB learning environment to support student engagement on environmental issues and sustainable living.

Designing sKBDS

In this section, we unpack the design of sKBDS based on two knowledge building principles: community knowledge, collective responsibility and knowledge building discourse.

Evolving special-interest groups within the community (Community knowledge, collective responsibility). sKBDS was intended as a space that centred around students' voices, capturing their ideas, questions, and contributions as the main design focus. sKBDS emphasized the roles of students as contributors to the community, producing ideas of value to the society and for the public good. KF was used to create the open community discussion space where every member of the sKBDS, students and experts (teachers, scientists, researchers, for example), actively contributed and built on each other's knowledge. We leveraged KF to identify emerging students' interest in sustainability issues through evolving Special Interest Groups (SIG) workspaces. Members can move around to discuss ideas across different groups and bring feedback to their group to deepen the topic of interest. We hope to support students in taking on a higher level of ownership through this evolving grouping structure during collaborative learning.

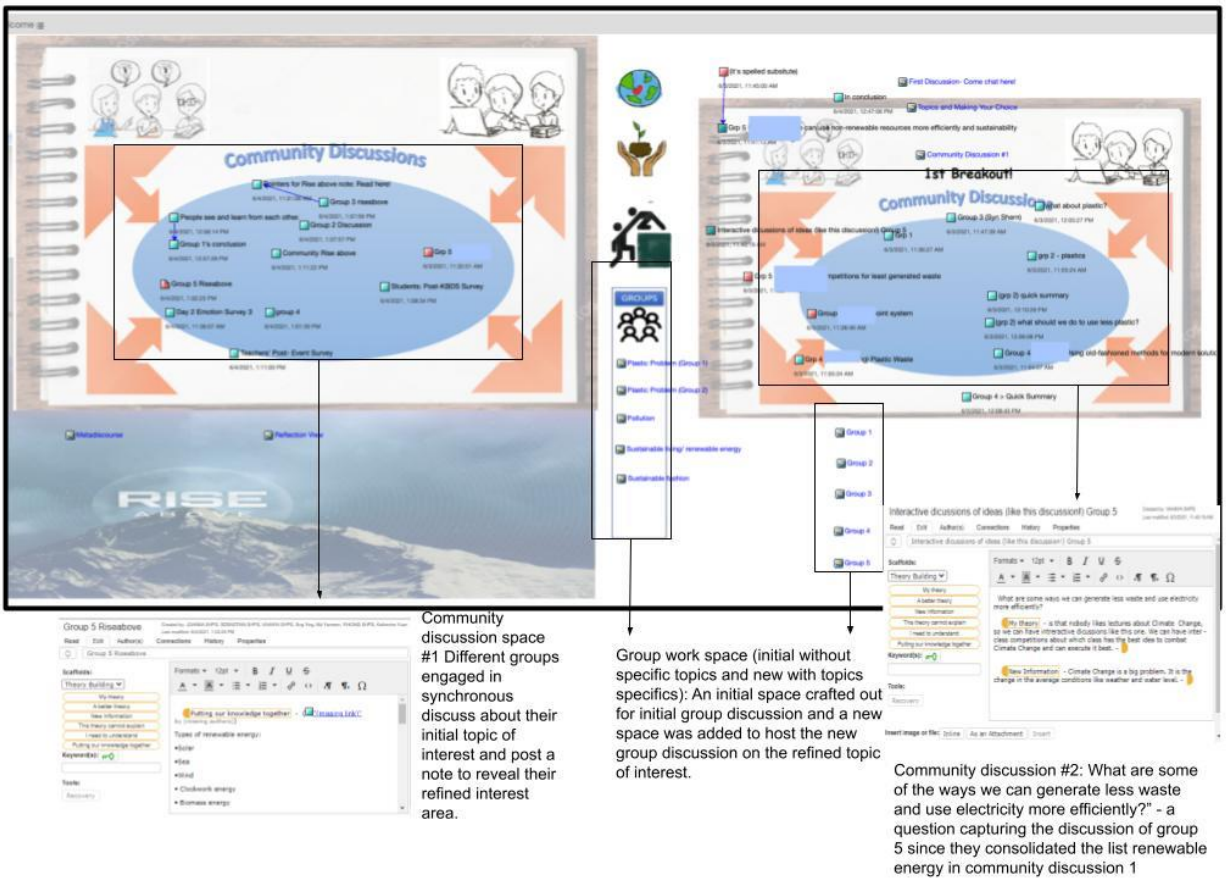

Figure 1. KF view is designed with different community discussion space to encourage collaboration and

cross-community sharing. Evolving group workspace captures emerging students' interest for further work. The students generated five big ideas on sustainability, including plastics, pollution, sustainable living/ renewable energy, and sustainable fashion.

KB discourse. sKBDS was intended to focus students primarily on the discourse as the end-product. This is a deviation from typical learning outcomes that students are used to in their classroom. The principles of KB discourse emphasize the community's discursive practice as a way to refine and transform the knowledge. Guided by KB discourse, the aim of engaging students in these discourses was not to impart knowledge from experts but to support students in reflecting and improving on their ideas based on community feedback. In the sKBDS, we explained to students that they could put up any ideas or questions, we encouraged them to put in the effort to think about every idea that went into the community and how each idea contributed to the class' inquiry. We invited experts to connect with the student community so that the young students can immerse in the ways of thinking like the expert. We also utilized a set of KB scaffolds (Figure 2) to help students build their ideas. Analytical feedback, such as scaffold frequency usage, was also put up on KF to support students in reflecting on their discourse contributions (Figure 3). This was to support students in moving beyond sharing ideas to improving their ideas.

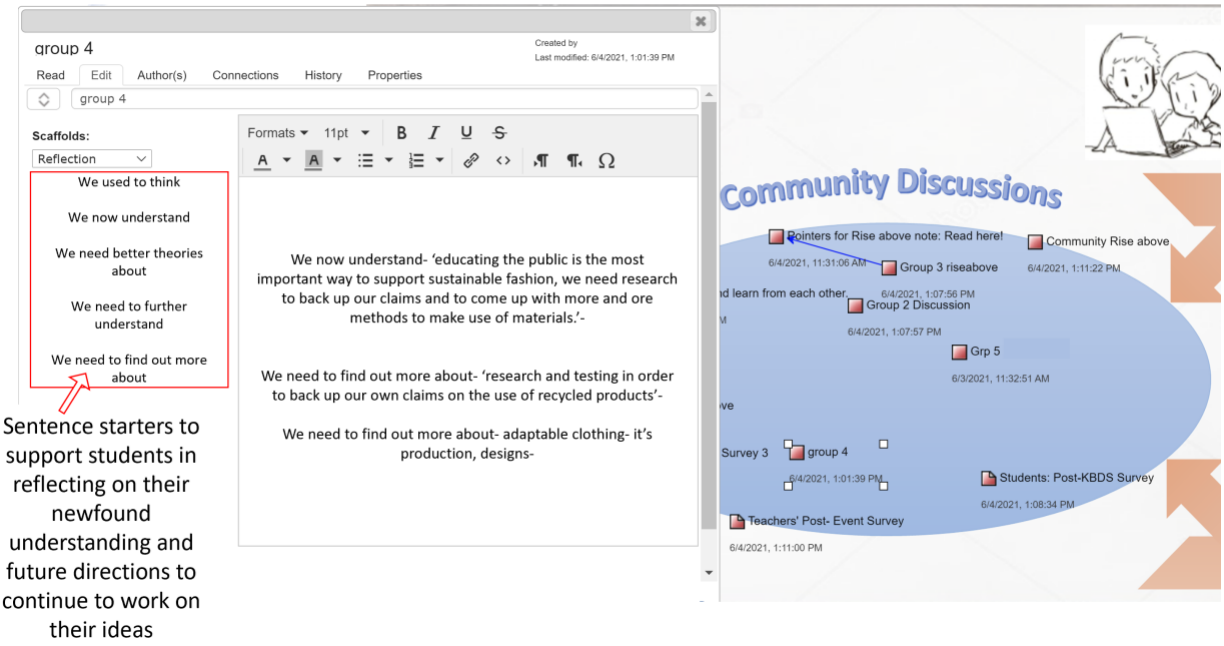

Figure 2. KB scaffolds to support students in reflecting on their newfound understanding and future directions with an example of a post from a student utilizing these scaffolds.

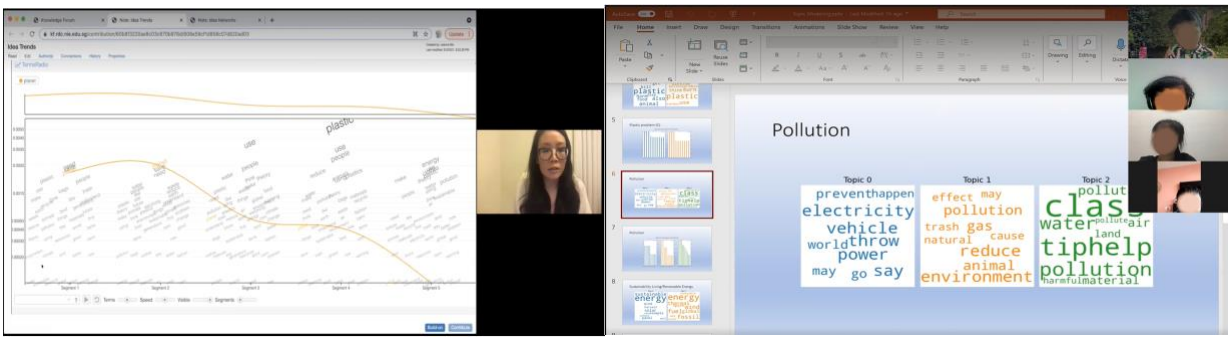

Figure 3. Analytics feedback: in the form of playable analytics, provided to students to support students in reflecting on their discourse contributions.

Research Question.
We explored the following research question: How do the students ideas vary in the different dimensions of novelty as students engage in the sKBDS?

Method

Context. Thirty-two students from six schools came together for two days to work on the theme of 'Saving Planet, Saving Lives'. Students first worked in random groups to generate ideas on the themes or big ideas they wanted to work with as a community. Special interest groups were formed based on emerging big ideas from the initial discussions so that students have opportunities to inquire and delve deeper into areas of their interest. A challenge for students was to develop an artefact to represent their ideas on sustainability. Students interacted with peers from different schools and grade levels, teachers, researchers, and scientists throughout the two days. The interactions were supported by online zoom discussions (community discussions and breakout groups) and KF discussions.

*Data and analysis***.** We analyzed the following Knowledge Forum notes across three views:

1. Main community discussion view: 14 notes in the first community discussion were analyzed for diversity of ideas on the theme of 'Saving Planet, Saving Lives'.
2. Group discussion views: 135 students' notes across their group's interests were analyzed for idea improvement.
3. 6 Group reflection notes.

We coded the KF notes using a novelty analytic framework (Yuan et al., 2021) and studied the content of students' notes contribute to the community along the five dimensions, namely:

(a) New concept: student shares a new idea/topic, expands an existing idea with a new idea or provide a different but related idea - all that has not shown up before in the Design Studio discussion.
(b) New connection: student connects two existing ideas or provides a new connection to an existing idea.
(c) New Rise-above: student posts a new integrated idea with insight from existing ideas.
(d) New question: student posts new questions.
(e) New context: student suggests a new or different context.

To provide ease of comparison, we segmented the student discourse in the design studio into four phases. For each dimension, a "0" represents no new contribution in the respective dimension, a "1" represents some level of new contribution and a "2" represents a substantiated note contributing to the respective dimension. A time sequence analysis was combined with the analysis on students' novelty contributions for each dimension, as shown in Figures 2a to 2e.

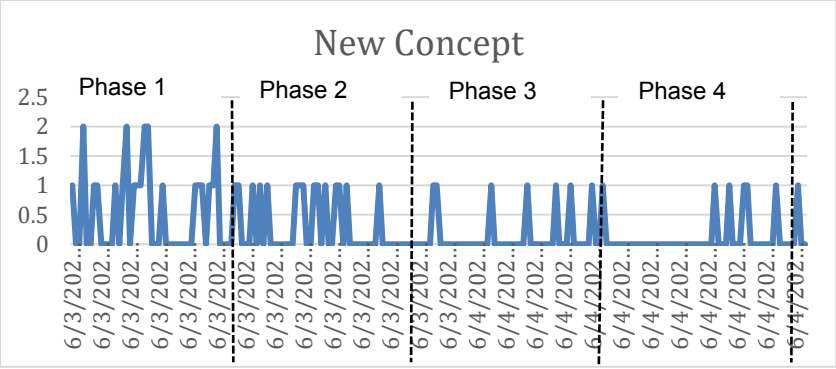

Figure 2a. Students' contributions of new concept and its creation time in KF.

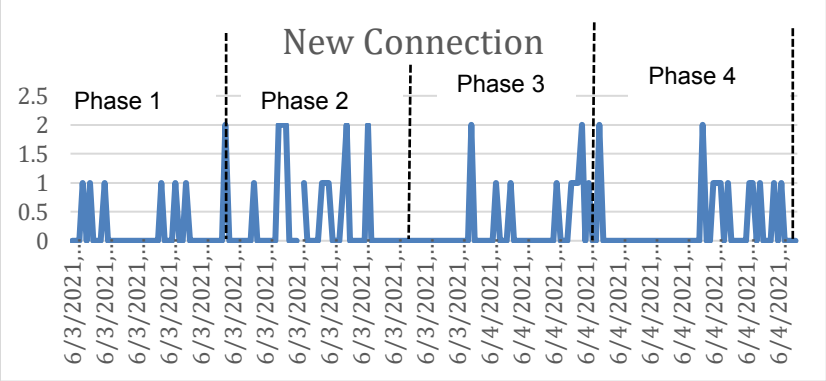

Figure 2b. Students' contributions of new connection and its creation time in KF.

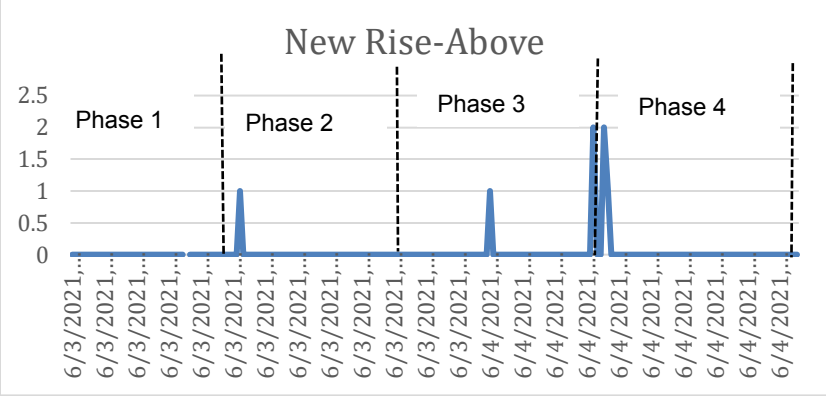

Figure 2c. Students' contributions of new rise above and its creation time in KF.

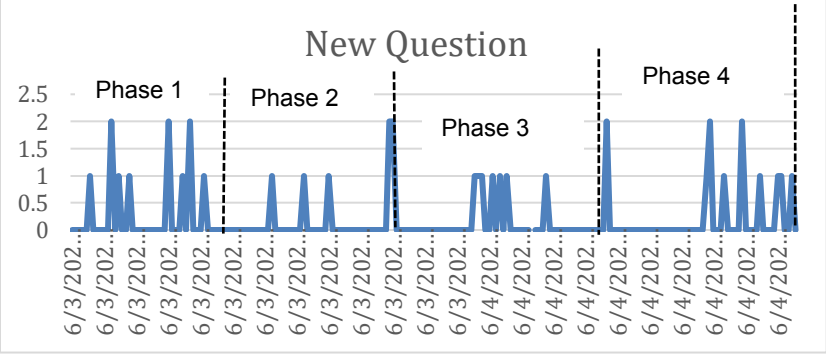

Figure 2d. Students' contributions of new question and its creation time in KF.

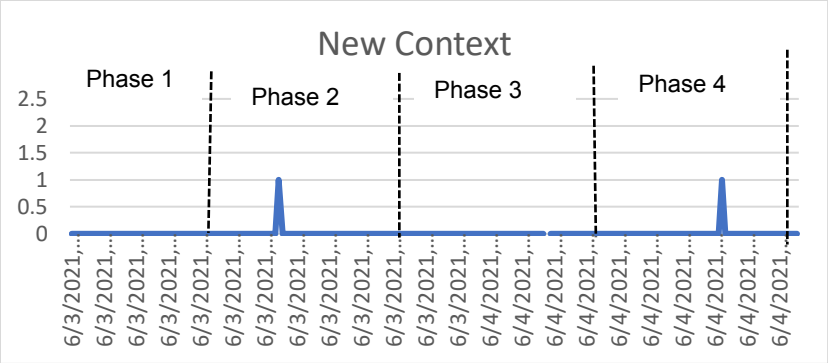

Figure 2e. Students' contributions of new context and its creation time in KF.

(i) At the beginning of the sKBDS (phase 1 and phase 2), students were seen to be contributing new concepts and new questions at both new and substantiated levels. This was followed by an increase in New Connection, which suggested an effort to build the community's knowledge in phase 2 and 3. The analysis showed that more substantial new-questions started in phase 4, showing an encouraging trend of students' effort to advance the inquiry as they progressed in the sKBDS. The new-questions category revealed a consistent emergence of new questions throughout the whole design studio.

(ii) The contributions of new rise above and new context were reflected in phase 2 and 4. Although low in frequency, the results indicated a deviation from usual classroom practice where summary and synthesis of ideas were only done at the end of lessons.

(iii) At the mid-point of sKBDS (phase 2 and phase 3), the contributions of new-concept and new-connection reflected was sustained and led to a new-rise-above at the end of phase 3. This revealed efforts to accumulate knowledge.

(iv) Towards the final phase, non-substantiated notes with new-concept and new-connection began to appear again at a consistent rate, which indicated that students continued to generate new ideas throughout the sKBDS but likely lacked sufficient time to deepen the inquiry. This led to an understanding of the mini-cycle in pt (v).

(v) There seemed to be a repeating pattern of mini-cycles of non-substantial, new and substantial notes in new-connection and new-question but not in new-concept. This may suggest some building up of knowledge, but, unfortunately, there is no specific indicator of significant breakthrough throughout sKBDS. The design studio might not have provided sufficient time for students to work on the ideas and thus ended with a relatively simple solution. The design could also be strengthened to support more regular and frequent new-concept and new-rise-above in the community.

Illustration of an episode of students improving ideas in sKBDS: The novelty analysis shows a positive trend towards new and creative solutions generated by students at the sKBDS but indicated space for improvement of design and engagement. The positive trend can also be seen in specific group's idea progression. In the e-fashion special interest group, students started by contributing ideas and questions on fashion (*new-concept and new-question*). Some of the questions that the students voiced out were "why people discard their clothing?", "are there are alternative materials to create garments?" and "how can we encourage people to use more sustainable fashion?". Students led the various discussions on the aspects of fashion they were interested in. The group discussed several reasons for clothes wastage such as the discarding of clothing that no longer fit (*new-connection*). Students derived ways to resolve the problem by sharing how they repurposed fabric and remained fashionable, e.g. converting a blanket into a skirt (*new context*). The discussion built towards new ideas on rental services to counter the problem of clothes wastage (*new-connection*). Students continued to suggest different solutions such as free trials to encourage

people to move towards more sustainable fashion behaviours (*new-connection*). They realized that sustainable fashion requires deeper consideration of many other factors including sustainable and recyclable materials, repurposing and education (*new Rise-above*). In the final discussion in sKBDS, the group continued to generate ideas for sustainable clothing, such as using pineapple leather to replace cotton, but these ideas were not quite substantiated like the earlier ideas (*unsubstantiated new-concept*). The group collectedly reflected that they needed to get more information and to use more methods to drive their proposal on e-fashion as a solution for sustainable living (*new-rise-above*), "we need research to back up our claims and to come up with more and more methods to make use of materials...we need to find out more about- research and testing to back up claims on the use of recycled products."

Conclusion

Students actively engaged in discussions on sustainability issues over the two-day student Knowledge Building Design Studio. The two Knowledge Building principles, embedded into the sKBDS design, supported students' deeper engagement with sustainability ideas. The principle of community knowledge and collective responsibility supported students to create diverse ideas about sustainability issues that truly mattered to them. The principle of Knowledge Building discourse supported students in inquiring deeper into their sustainability ideas. The positive findings on the novelty and substantial ideas that emerged from the discussion serve as a strong encouragement for scaling such initiatives to a broader community. Future iterations of the sKBDS can investigate cross-SIG interactions, and through such interactions, students can understand ideas across the different environmental issues. However, the design could be further improved to provide sufficient time for breakthrough ideas and sustained inquiry.

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POSTERS

Supporting student agency in Knowledge Building in a linguistically diverse secondary science classroom

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Research Summary

The issue

The learning curve facing newcomer plurilingual students in UK secondary school is steep; they have less than two academic years to prepare for A-level examinations. They have studied science at secondary level in another language so they need to be able to leverage the subject knowledge and study skills they already have, and to believe they have agency and the tools to enact it. How best can teachers support student agency in the context of a linguistically diverse Year 12 science classroom in the UK? My research aligns with KBSI2021 Theme 3: A rising Knowledge Building Tide Lifts All Boats.

Major goals

To explore how Knowledge Building (KB) in Knowledge Forum (KF®) can support student agency in a linguistically diverse secondary science classroom in the UK.

To explore the extent to which Knowledge Building in the KF® space can fast-track plurilingual students new to the UK and enable them to participate in collaborative knowledge building and exceed curriculum expectations.

How the research addresses the issue

I am taking a multi-disciplinary approach to explore this issue because the application of Knowledge Building principles and dialogic education theory to bilingual education has potential to create an equitable learning environment in linguistically diverse classrooms, where all students have a sense of agency and can enact it (Asterhan et al., 2015; Clarke et al., 2016).

There are well-established theoretical and empirical connections between Knowledge Building and dialogic education which highlight the benefits for learning of dialogue (Mercer & Littleton, 2007; Phillipson & Wegerif, 2017) and the value of discourse for collaborative learning (Scardamalia & Bereiter, 2010; Scardamalia & Bereiter, 2014; Chan et al., 2019). In Knowledge Building, the principle of student epistemic agency emphasises the control students should have over the tools and skills they need to build collective knowledge (Scardamalia, 2002; Bereiter et al., 2016). The KB principles of democratizing knowledge and symmetric knowledge advancement reinforce the value of student agency in collective endeavour (Scardamalia & Bereiter, 2010).

Agency is also important in bilingual research (van Lier, 2004; 2010) but, while some studies have investigated the application of Knowledge Building principles for English language learning (Manegre et al., 2019), and interest in crosslinguistic instructional strategies for scaffolding is evident in current bilingual education research (Le Pichon et al., 2021), the affordances of Knowledge Building and Knowledge Forum® have not been fully recognised in this field. This is surprising, especially from the viewpoint of translanguaging pedagogy and crosslinguistic translanguaging theory (Cummins, 2019; Cummins, 2021), given the scaffolding Knowledge Building and Knowledge Forum® provide. The customisable nature of the KF® scaffold sets, for example, means the type of support they provide can be adapted to student needs; in this case, they can be used as linguistic support.

Pilot study: key findings

My pilot study took place in April 2021, in a linguistically diverse Year 12 Chemistry class. The collaborative enquiry-based learning task was undertaken in KF and called on students to choose two equations from a selection of four to explain Le-Chatelier's principle of chemical equilibrium.

The class of 11 students aged 16 to 18, included three plurilingual students new to the UK who do not have English as a home language and had no prior experience of the UK education system and three plurilingual students who do not have English as a home language but had been in the UK education system since Year 10. The Common European Framework of Reference (CEFR) levels of the plurilingual students ranged from A2/B1 to C1. The group also included five students who have English as a home language and have studied in English since they started their education.

The students were interviewed before and after the collaborative task about their sense of agency in their Chemistry class. Their responses and verbal student dialogue recorded during the collaborative activity provided qualitative data. KBDAC, KBDEX and pre- and post-task test results provided quantitative data. All the plurilingual students had access to a customised set of bilingual scaffolds (Mandarin/ English).

After initial one-to-one interviews with the students on their sense of agency in their Chemistry class, the activity started with a plenary discussion to negotiate the ground rules for a successful collaboration. This was followed by a software familiarisation activity in KF®. The Chemistry teacher went on to outline the details of the task and the students completed a pre-task Chemistry quiz related to the topic designed to test content knowledge. They were then allocated to one of three groups chosen by the teacher and spent two lessons working in KF on the collaborative task. After the last session, the students completed a post-activity test of content knowledge and were interviewed about their experience of agency during the activity.

Qualitative interview data was analysed by theme and collaborative dialogue was coded for productive talk using the Scheme for Educational Dialogue Analysis (SEDA) (Hennessy et al., 2016; Hennessy et al., 2020) and the Cambridge Dialogue Analysis Scheme (CDAS) (Vrikki et al., 2019). Analysis tools in KF® included in the Knowledge Building Discourse Analysis Center (KBDAC), such as student profiles and the scaffold tracker, and the social networking analysis tool, Knowledge Building Discourse Explorer (KBDEX) (Oshima et al., 2012) (Oshima et al., 2020) were used to analyse the quantitative data generated by student activity in KF®.

Four key findings from this pilot study are summarised in Table 1.

Table 1: Key Findings.

Finding 1	Finding 2	Finding 3	Finding 4
Data in the student profiles in KBDAC, showed how plurilingual students enacted agency, by reading the contributions of others as well as making their own. All of the plurilingual students read more notes than they wrote which highlights the benefit to them of having this knowledge 'visible'. These data were compared to the views they expressed during interviews about their sense of agency.	KBDEX was a valuable and robust tool for exploring the complexities of group collaboration through a 'knowledge building' learning metaphor (Oshima et al., 2012), and complemented the coding of verbal and non-verbal dialogue. Data on group cohesion in KBDEX showed that the group was building content knowledge in KF, even when the coding of the verbal dialogue in the group did not clearly show this to be happening.	In this linguistically mixed classroom, the most linguistically challenged students used the bilingual scaffolds (Mandarin/ English) and reported finding them useful. They also found the initial focus on 'ground rules' for collaboration reassuring in that contributions were expected from all and valued.	The nature of the collaborative dialogue between the teenagers highlighted the need to pay attention to the social factors which can enhance collective knowledge building in teenage interactions (Ahmed & Johnson, 2019).

Next steps

My doctoral design-based research project started in October 2021 and data collection will take place in three cycles over two academic years.

Reflections

Reflections to take forward to the main study include:

- the potential of KF® to both minimise and add to intrinsic, extraneous and germane cognitive load (Sweller et al., 2019) and collaborative cognitive load (Janssen & Kirschner, 2020) for plurilingual students. Despite the impact of spilt-attention, for example, the visbility of ideas in KF® can support plurilinguals;
- the potential to support language development not only through bilingual scaffolds but through translations tools;
- the potential to refine assessments of plurilingual student language by using the Reception, Production, Interaction and Mediation descriptors outlined in the 2018 CEFR update(Council of Europe, 2018).

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COMPARING PERSPECTIVES IN TIMES OF PANDEMIC

Laura Calzado - Jenny Melo

A project done in times of pandemic,, that shows how important is to connect with people around the world , and led students explore similarities and differences among schools, countries and life styles.

CONCEPTS WORKED

- Bogotá and Barcelona city description
- Manners and cultural expressions in both countries
- What makes our schools so nice to study at?
- What are are daily live routines?
- Differences and similarities in our schools & counties

PARTICIPANTS

- 62 students from Bogotá and Barceloma
- 7 English language teachers from both cities
- Gimnasio La Montaña school from Bogotá and Dolors Monserda Santapau school from Barcelona

PROJECT OBJECTIVES

*To provide cultural exchange about school life and personal life.
*To create an international environment so that exchanges are promoted and students can foster their plurilingualism.
*To boost students' oral and written communication skills in English.

INTERCULTURAL EXCHANGE PRODUCTS

2 video conferences
postcards sent to Barcelona students
Interactive Game proposed by Barcelona students
City facts presentation
Video reporters

KNOWLEDGE BUILDING

This project followed the principle REAL IDEAS, AUTHENTIC PROBLEMS, because the work was focussed on a real issue: The pandemic. Both communities build upon products exchanged and video conferences ideas of how they live their lives nowadays.

REFLECTIONS

- It is hard but rewarding to work on a collaborative project under the pandemic conditions
- It is needed a kid-friendly online forum where our students can builg upon other´s ideas and can get introduced to the KB principles.

Analytics of Object-Centered Sociality in Knowledge Forum

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David Groos, Minneapolis Public Schools, djgroos@gmail.com

Research Summary

Statement of the issue/problem: "Did my students read notes? Did my students write notes? Who did/didn't?" These are simple but important questions a busy teacher wishes to answer when doing Knowledge Building (KB) (Diaz del Castillo, 2021). The KB community is in need of both novel indicators that depict important characteristics of a classroom and actionable representations of such indicators.

Major Goals: This poster aims to achieve two goals: (1) advancing analytics of object-centered sociality, and (2) prototyping analytic tools that may help a teacher answer simple questions about their class.

How the research addresses the issue/problem: The notion of *object-centered sociality* is based on the intense relations between humans and objects in knowledge work (Knorr Cetina, 1997). While objects of interest here could be both tangible (e.g., particle detectors) and non-tangible (e.g., string theory), in Knowledge Forum (KF) one important type of objects is KF *note*. Several key questions facing a KB classroom are: (1) *How are notes connected with each other?* (2) *How do students socialize with notes?* (3) *How are students related to each other based on their socialization with objects?*

Advances–what has been learned to-date: To answer these questions, I apply network analysis to a KF dataset from five classes. First, to depict how notes relate to each other, I construct a build-on network of notes for each class and analyzed its motif distribution. Motifs, defined as recurring patterns of a network, enable us to characterize and discriminate networks (Milo et al., 2002). Using the distribution of motifs in the note network, we characterize note connections in a class. Second, to describe a student's relation with a note, I encode three key actions—*read*, *write*, *build-on*—into a 3-bit binary number ('RWB'), which can be converted to a decimal number. For example, if a student has read and built on a note, the student–note relation will be coded as '101' and converted to 5. In KF, RWB has five possible values indicating different association levels: 7—'rwb' (one builds on one's own note), 6—'rw-' (one's own note), 5—'r-b' (read and build-on a peer's note), 4—'r--'(read a note), 0—'---' (no relation with a note). As such, a student–note association matrix can be created. Based on this matrix, we can characterize students' association with KF notes at both collective and individual levels. Finally, a student–student network can be derived based on the similarity of their relations with notes, providing a distinct type of sociality in KF that is based on objectual relations (instead of social interactions).

Preliminary results are presented in Figures 1-4. In Figure 1, motif signatures of the build-on networks of notes show that two classes, P1 and P7, had large proportions of isolated notes or note-pairs, while the other classes had more sophisticated structures such as 'chains' (of 3 and 4 notes) and 'trees' (balanced and unbalanced). Figure 2 presents the student–note association matrices from two classes, P2 and P6. With the *x*-axis representing students and the *y*-axis representing notes, the visualization reveals collective attention to notes in each class. P6 showed more intense student–note relationship important for KB, whereas P2 had more students who built on their own notes. At the individual level, Figure 3 presents visualizations of individual attention derived from the matrices. In the graphs, each horizontal bar represents one student, with color representing the RWB value and hence the nature of association. There were students in both classes who read a number of notes but didn't contribute, as well as students who contributed notes without reading their peers' notes. In Figure 4, student networks derived from one class' student–note association matrix is presented side-by-side with the build-on network of students. Some students (e.g., #17 and #18) are isolated in the build-on network but connected with each other (and also with others) in the network based on shared attention, indicating hidden potential of collaboration.

Next steps: This work is an initial effort to advance analytics of object-centered sociality in KB. While there are rich opportunities to deepen the analysis (e.g., incorporating temporal and textual data), we also need to evaluate usefulness of the introduced analytic information and usability of the representations (e.g., in Fig. 1 and 3).

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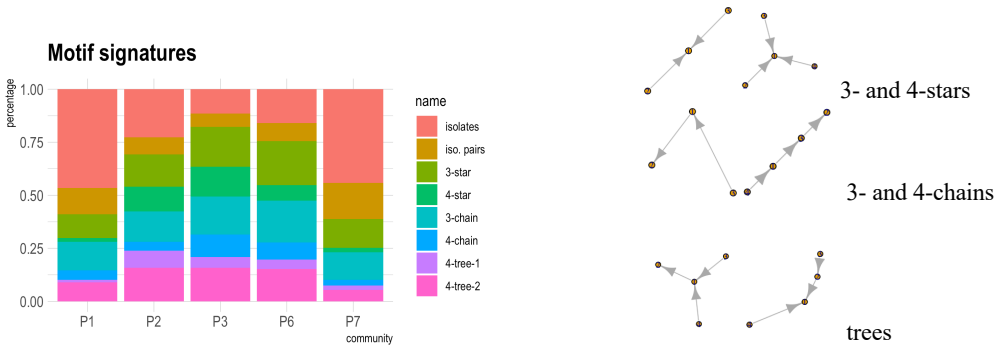

Figure 1. Motif signatures of all classes.

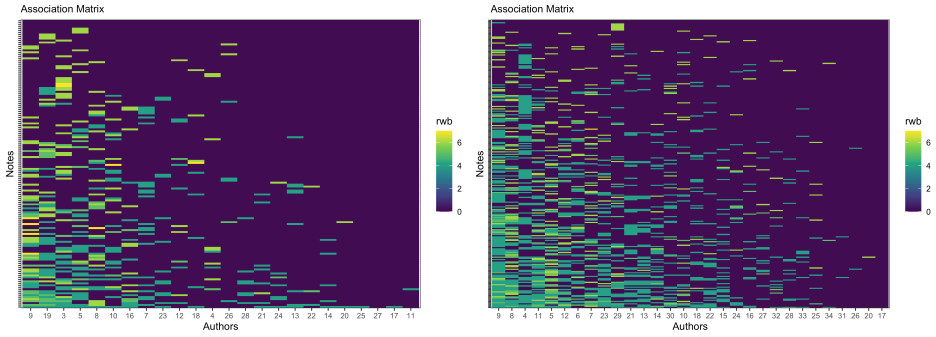

Figure 2. Student–note association matrices of two classes (P2—left; P6—right).

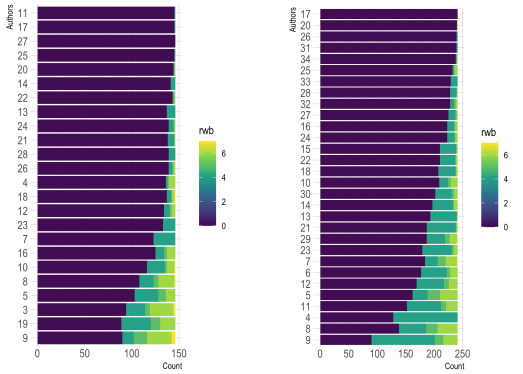

Figure 3. Each student's association with notes in two classes (P2—left; P6—right).

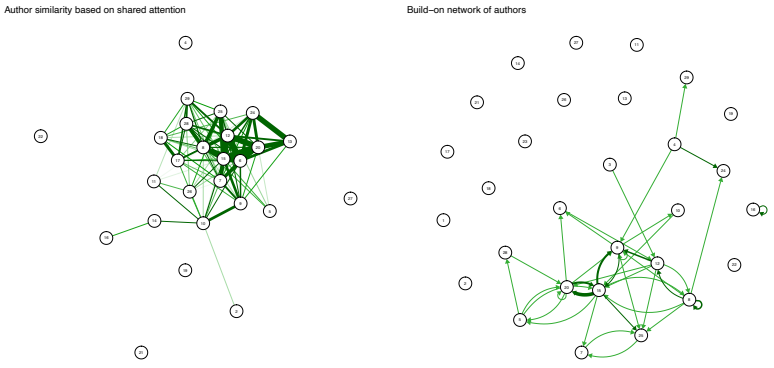

Figure 4. Student networks (of P1) based on shared attention vs. build-on interactions.

Accessing and Building on Public Knowledge Created by Children as a Means to School System Regeneration

Niall MacKinnon, Avernish Prospect, info@avernish.co.uk

Rationale of poster: Following a two-year national conversation 2002-04 a review and proposals report 'A Curriculum for Excellence' (Scottish Executive, 2004) set a new direction for Scottish school education. It was conceptually and structurally innovative, envisaging radical reform, whilst emphasising considerable existing strengths within the national education system to be drawn on.

Its central goal was for schools to foster 'Four Capacities' of children's potential as 'Successful Learners, Responsible Citizens, Effective Contributors, Confident Individuals' along with personal descriptive attributes and capabilities. Seven principles of curriculum design were set out with layered conceptual and operational components. A developmental process 'Building the Curriculum' (Scottish Executive 2006, 2007, Scottish Government 2008, 2009, 2010) of five themes was framed by reflective questions. Schools and councils were to own the detailed construction process, moulding it to their individual circumstances and needs. This was to be undertaken over five years to 2010. I took up the post of head teacher Plockton Primary School in summer 2001. We were closely involved in these national processes. The local authority was supportive with structured processes of development planning and special initiatives (e.g. Highland Council 2005). The national curriculum agency offered guidance, grants and publications of local development initiatives (e.g. MacKinnon 2004, 2006a, b). The curriculum framework 'building' process was to be formative and collaborative within and between all levels of the system, as was the terminology utilised. In undertaking this approach in Plockton we worked with partner bodies, businesses, community organisations, software companies and schools, near and far.

A countervailing tendency arose from mid-2005. Local council 'Quality Assurance', national HM Inspectorate and Care Commission inspection methods utilised intensifying methodological instruments as micro-levelled 'performance/quality indicators' of idealised standardised descriptors, applied through 'snapshot' judgment. These set up a functional and ethical problem as 'Nigel', a rural Scottish primary school head teacher, recounts in Ball's (2015) paper: '"I am a victim of the 'terrors of performativity' [Ball 2003]. The notion of calibrating performance sets in stone what is to be measured and how, and also gives power to a cadre, who are handed the status of determinators. Hubris takes over, just as so too interpretative awareness and social insight implode."'

Supposed objectivity of scrutiny belies conceptual and theoretical mismatch for school reform (MacKinnon 2011), of which MacBeath and Moos (2011) observe: "Niall Mackinnon's primary focus is on an accountability culture in which he depicts school inspection as increasingly tightly coupled with standards, indicators, together with a 'dirigiste' self evaluation framework which, he contends, has lost much of the vitality and spontaneity of what once was. His argument is not for less accountability but for what schools need to do to become 'account able', that is, furnished with the tools, frameworks, courage and resilience to compose their own script, to tell their own story."

For Sahlberg (2011, 2015), 'Niall MacKinnon, who teaches at Plockton Primary School, makes a compelling appeal for "locally owned questions and purposes in realising practice within the broader national policy and practice frameworks (MacKinnon, 2011, p. 98)" to circumvent the Global Educational Reform Movement or GERM (Ibid; MacKinnon 2011a,b,c,d). McAulay (2020) observes: "MacKinnon's [2020b] paper deals with a third example of tension, in this case between implementation of a significant reform in a Scottish school and the audit and accountability processes mandated by the larger system. Also mandated by the larger system, while successful locally and shared globally, [it] failed because it was not congruent with the practices for assessing it." "The audit managerial monolith" ('Nigel' in Ball 2015:9) needs "accountability in design mode" (MacKinnon and Mizzi 2021).

In Plockton Primary School we 'built' the curriculum framework in accordance with the review principles reinterpreting curriculum as a framework not as delivery or performance (MacKinnon 2015a, b, c). I summarised tensions and potentials in our system at KBSI 2014 (MacKinnon 2014b). My poster here is a prompt for realignment of Scottish school education to the original 2004 review intent via Scardamalia's (2002) Knowledge Building Principles, the Freedom to Learn Manifesto (2016) and formative imperative to 'study the work', 'get knowledge' and 'absorb variety' in system terms as per The Vanguard Method (Seddon 2008, 2014, 2019; MacKinnon 2014a, 2016, 2018b, 2020a, b). In May 2011 a school pupil presented a web report 'Growing Green' (Plockton Primary School 2002-16, 2011) of the school's activities in horticulture, related collaboration via the international Thinkquest virtual environment (Ibid; Oracle Foundation 2007, 2009) and a website which he and a team of three devised and made. They owned the task as purpose, method and means. A different mindset rediscovers the children and teachers as they really are, in their terms: "get to know those pupils, and those staff, and you will find they have genuinely excelled themselves in what they have achieved, over time." ('Nigel' in Ball and Olmedo 2013:92)

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Accessing and Building on Public Knowledge Created by Children as a Means to School System Regeneration

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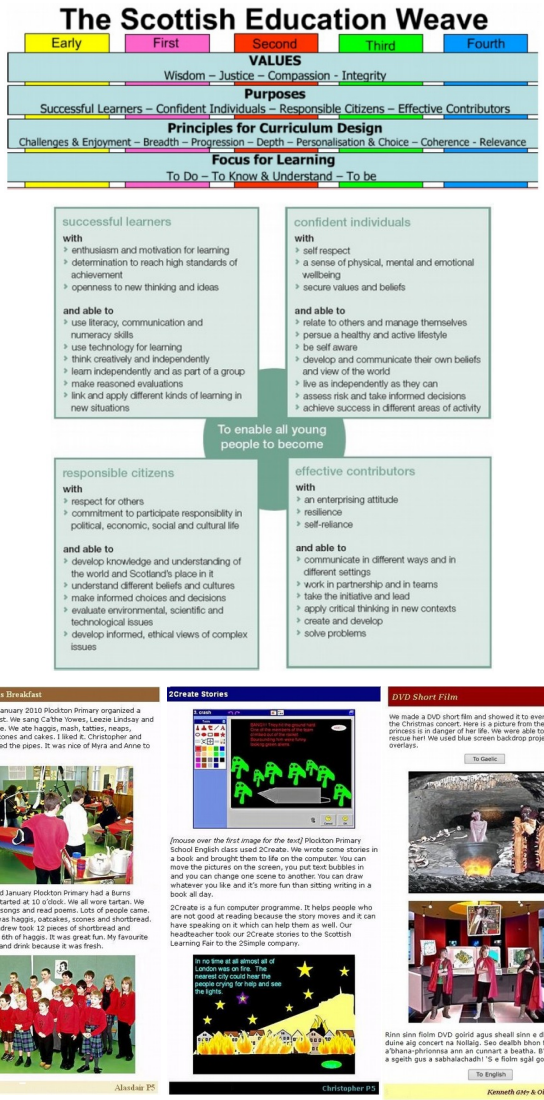
David Nelson Trophy winners


Victorian classroom


T-shirts play


Film animation



Stories for animated films written by P5-7, Plockton Primary School

Stories illustrated animated by pupils using 'Revelation, Sight and Sound' software.

Translated into French also with French sound track for sending to French Partner school for them to watch and listen to our stories written by Plockton pupils, but in French.

Exchange of letters between pupils.

We watched the film they made and sent to us.

Rhiannon

by C

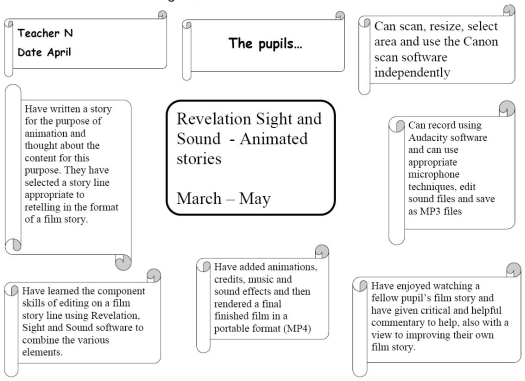
Rhiannon walked happily along the dusty track on her way to the big outside swimming pool. The ground was boiling hot. All the mud had cracked and from above must have looked like fish scales. Her glossy black hair was too hot to touch and her tanned skin was frazzling…

Rhiannon

de C

Rhiannon marchait tranquillement le long du chemin poussiéreux qui menait à la grande piscine. La terre brûlait sous ses pieds. Toute la boue était fissurée; vu d'en haut ça devait ressembler aux écailles d'un poisson. Ses cheveux noirs brillaient – on ne pouvait pas les toucher – tellement ils étaient chauds – et sa peau bronzée brûlait...

Note: idiomatic English and French



How to Support Knowledge Building among Deaf and Hard-of-Hearing College Students in a Graphic Design Course?

Qifeng Man, Yibing Zhang, Nanjing Normal University, Nanjing, China
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Research Summary

This study explored some instructional approaches and tools to support knowledge building among deaf and hard-of-hearing (DHH) students in a special education college, including the use of comprehensive communication mode, scaffolds which can help them visualize their ideas, and demonstration discussions and comments in Knowledge Forum (KF).

Statement of the issue/problem:

How to support knowledge building among DHH college students in a graphic design course?

Major Goals:

We hope to find some useful instructional approaches and tools to support DDH students' knowledge building.

How the research addresses the issue/problem:

1.Participants

15 DHH students who have varying degrees of hearing loss.

2.Process

Teachers and students spend an afternoon each week studying chromatics in graphic design course. The whole teaching process can be divided into four stages: reading materials, choosing the topics and forming groups, forming questions and expressing ideas, improving ideas and theory building.

3.Supports

(1) Comprehensive communication mode

The teacher communicates with students by oral language, sign language and written language. Teacher also uses speech-to-text tools to show his ideas or suggestions on the screen. Throughout the process, teachers and students have been using KF to write notes and use it as an online communication space.

(2) Scaffolds

The teacher provides specific scaffolds and help students express their ideas visually:

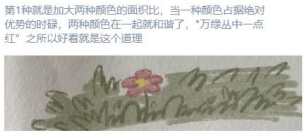
My problem is:(Writing the term or other contents which you don't understand after reading)

What is complementary color?

My idea is: (Writing your idea of the problem using your own words, it can be simple; Try to visualize your idea)

Complementary colors are paired colors…

Application of my idea is: (Apply your ideas to your graphic design works or find examples which applied your ideas)



(3) Demonstrate how to discuss and comment in KF

The teacher shows the DHH students how to discuss with others and to comment on others' ideas in KF to help them to improve ideas.

Advances–what has been learned to-date:

Notes in KF showed the instructional approaches and tools are helpful for DHH students to understand color and improve their ideas. Comprehensive communication mode and scaffolds which can help them visualize their ideas made it easier for them to understand, express and improve their ideas. They also have learned how to discuss constructively with the help of teacher's demonstration.

Next steps:

In the future study, more instructional approaches and tools need to be developed to support the idea improvement of DHH students. DHH students' changes in KB class are also worth studying.

Here and There: Community for Everyone, Everywhere

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Our Authentic Problem/Challenge:

As part of a virtual event for the Global Knowledge Building Design Experiment which took place in spring 2021, I was invited to speak about the collaborative design process that involved connecting with teachers, researchers, and local experts to advance grade 2 students' Knowledge Building about salmon. After this event, a teacher-researcher team from Barcelona connected with me to discuss opportunities to collaborate during the following school year. Our design challenge is to teach similar concepts in our classrooms and observe how our students would take up the same "big questions" in different contexts. I found this to be an intriguing approach to co-teaching because it would open interesting avenues for discussions and allow ways for the children to learn with and from other children around the world – they can simultaneously build knowledge in their own community whilst exchanging ideas with another community. Thus, this emergent partnership aims to advance the conference theme of "Meeting New People and New Ideas in Knowledge Building's Metaspace".

Major Goals:

My past work has focused on principles such as *epistemic agency, idea improvement*, and *constructive use of authoritative sources* (Nazeem, Zhu, & Ma, 2019). In my new work, I hope to take students' *Knowledge Building discourse* to the next level by emphasizing the principles of *democratizing knowledge* and *symmetric knowledge advancement*. It is my hope that this international collaboration will help advance my practices in two ways: to foster new relationships and to generate new ways of thinking about concepts in the Ontario curriculum. For example, recent work on cross-community collaboration has demonstrated the power of students working together to generate inquiry threads across the curriculum (Zhang, Yuan, & Bogouslavsky, 2020). This work also aims to set the stage for students working at the cutting edge of understanding – exchanging ideas not just with local communities but also with Knowledge Building communities around the world (Huang et al., in press). Throughout the school year, the teacher and I will co-design supportive environments for students to share the knowledge they are producing in intentional and purposeful ways with a global audience. The ultimate goal is to help students of all ages and backgrounds see themselves as knowledge creators.

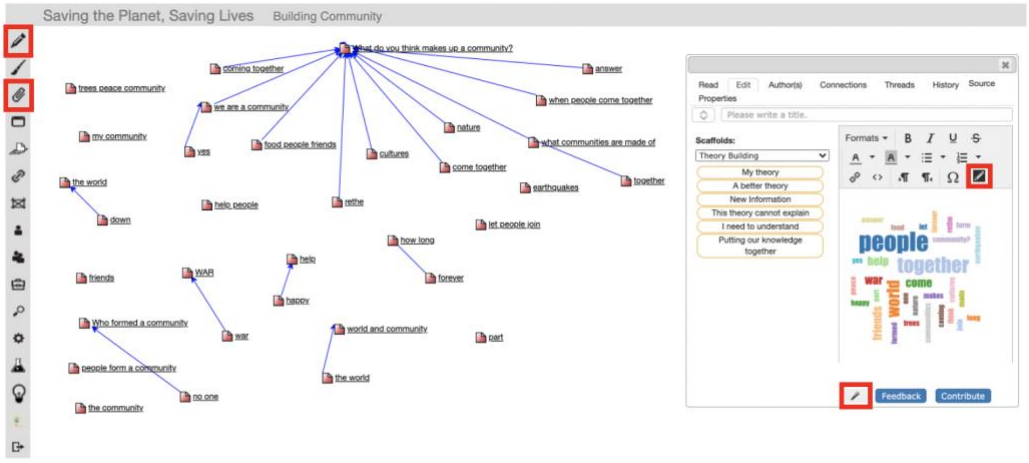

Figure 1. KF affordances for contributing ideas as text, drawings, audio, video, and other multimedia.

Promising Practices:

Over the course of the school year, we are planning to connect our classes on videoconferencing platforms to share our thinking and use Knowledge Forum (KF) to sustain collaborative work with ideas. Because I am working with grade 1 students this year, it will be their first time using Knowledge Forum. An added challenge is that students will be entering the school year in the pre-reading stage (Ontario Ministry of Education, 2003). Past work suggests that young students can indeed work productively with ideas when teachers scribe their ideas at school (Tarchi et al., 2013) or when parents scribe their ideas at home (Panju & Hoffman, 2018). Since there is not much work on the use

of Knowledge Forum with younger kids, it is my hope that this initiative can open possibilities to explore how KF can be used to bootstrap the development of 5- and 6-year-olds' reading, writing, and drawing skills. For example, Figure 1 shows new features in Knowledge Forum that can support contributing ideas in a variety of ways. On the left, children can contribute ideas as notes or attach multimedia (like photographs, audio clips, and videos) to the community view. On the right, children can use speech-to-text and create drawings to express their thinking. The word cloud tool can also be used on video transcripts of face-to-face discourse to help students recognize the spelling of "big ideas" in their community knowledge.

Reflections and Next Steps:

This cross-community initiative supported by synchronous and asynchronous collaborative technologies offers many opportunities to learn and innovate with our practices, but I also anticipate a few challenges ahead. One of the biggest challenges I face involves finding creative ways to use different modalities to engage students in the pre-writing stage to share and build on one another's ideas in Knowledge Forum. I see the drawing tool as an integral feature for supporting students in purposefully sharing their ideas with one another. How can the other features be used in tandem to support this goal without causing cognitive overload? I also anticipate that it will take more time for the younger children to complete and publish their contributions with the partnering school. What new designs and/or features can be developed to help facilitate this process? Lastly, this type of global, cross-community initiative is highly complex and emergent. I feel like teachers would also need time together to figure out how to create coherence among all the pieces and ensure that different voices in the community are represented in fair and comprehensive ways. Past work in the Knowledge Building International Project suggests that successful collaborations go beyond time management and coordinating schedules to interprofessional interactions that facilitate integration of the cross-community work into the school curriculum to enhance local resonance – when appropriate supports are provided at the administrative-level, this type of work not only benefits students' learning but also teachers' learning (Laferrière et al., 2012). I would love to receive feedback from audience members on strategies for fostering resilient cross-site collaborations, big questions that can engage students with ideas across the curriculum, and other strategies on how we could shape our inquiry in productive and self-sustaining ways.

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A Phenomenological Study into Curiosity and Confusion in Collaborative Idea Improvement among Elementary Students

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Research Summary

Problem Statement: Amidst our mission to reverse the learning losses due to COVID-19 lockdowns, student-driven engagement in collaborative tasks plays a crucial role as it leverages on the excitement that students feel when are reunited with their peers to enable them to take ownership of the learning process (Toth, 2021). Idea improvement in Knowledge Building (KB) allows educators to actualize this student-driven engagement within their classrooms in this new normal. It empowers students to navigate the process of bettering ideas with a design mode of thinking about a problem of understanding that stems from their curiosity (Scardamalia & Bereiter, 2017; Scardamalia, 2002). When this agency is provided to students during collaboration, they take on a responsibility to negotiate a fit between their ideas and 'contrasts' in the form of contradictory ideas from their peers (Scardamalia & Bereiter, 2017). These situations cause cognitive disequilibrium and is related to experiences of confusion (D'Mello & Graesser, 2012). In KB classrooms where "high-level controls" are turned over to students to resolve this disequilibrium (Teo, 2014, p. 225), logically, students should have more prevalent experiences with the aforementioned curiosity and confusion. Hence, understanding the nature of students' experiences with these epistemic emotions becomes critical. However, little is known about subjective experiences of these emotions during the idea improvement process (Zhu *et al.*, 2019), and most studies into learning involving design modes of thinking are from "high-level perspectives" which overlook episodic experiences (Zhang *et al*., 2020, p. 476).

Research Goal: The purpose of this study was to illuminate the phenomena of curiosity and confusion during students' idea improvement process as experienced by them. To achieve this purpose, this study adopted a hermeneutic phenomenological approach to explicate students' 'being-in', or *dasein* (Heidegger, 2010), within a Singaporean Grade 6 Social Studies lesson, where students engaged in a KB discourse in groups.

How the research addresses the problem: The main source of data came from interviews with nine students about their experiences of curiosity and confusion during idea improvement in a KB lesson. Only students who indicated high levels of these emotions in an in-activity survey were purposively sampled for interviews. Heideggerian hermeneutic phenomenology is used as an individual's actualization of his or her being-in (*dasein*) a situation is intricately connected to his or her emotions that are "attuned to how one is faring in the world with others" (Elpidorou & Freeman, 2015, p. 664). Using components of Heideggerian *dasein* as a primary lens, this study interprets the *dasein* of students from their experience of curiosity and confusion which are attuned to their "faring in" the idea improvement process. The findings offer insight into students' experiences through narrative, adding rich information for theory development and creation of pedagogical moves to improve idea improvement.

Advances: Most students reported their curiosity to be directed at their peers' ideas and this was related to practices that promoted idea improvement. However, one student who had contrasting ideas *vis-à-vis* his group mates recounted experiences with curiosity with terms that are more reflective of social emotions. He stated that he was 'lonely' as no one was "on his side", and that he was 'curious' as to how he could convince his peers of his ideas. Given the confluence with the social domain, a possible explanation would come from that of a 'socio-epistemic' dimension when students engage in idea improvement, where epistemic constructs might be intertwined with relationships students have with each other. This harkens back to Fleck's (1979) idea of "thought collectives", where he posited that when people engage in co-construction of knowledge, they become socially entwined into a community that has a particular "thought style" (p. 95). If this thought style is not shared by another, he or she risks not being accepted into the thought collective (p. 99). As such, one promising direction for research might be "thought collectives in the classroom" when students engage in collaborative idea improvement. For confusion, although there were students who rated a high level of the emotion, their experience of confusion differed. A few students used words of a higher intensity such as 'distress' and "being dominated", as compared to others who reflected they "weren't sure" or that they felt 'challenged'. Details of their recounts revealed that students who experienced a higher intensity of confusion were 'protagonists' whose ideas were at the centre of the discourse in that episode, while others were 'arbitrators', that is, they were part of the discussion, but on the periphery.

Next Steps: The iteration of next data collection will explore nuances between two types of confusion experienced, and also students' experiences at the intersection of social and epistemic domains of idea improvement.

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Higher education students perception of the Knowledge Building learning experience: Different levels of engagement within the Knowledge Building community.

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Research Summary

Statement of the issue/problem: Knowledge Building is a socio-constructivist pedagogy that aims to create educational environments supported by technology that enable the formation of educational communities which promotes students' empowerment (Scardamalia & Bereiter, 1994). However, knowledge building implies a high level of participation and this can provoke different reactions in students. Some learners may respond positively while others may show resistances to new learning approaches (Tolman & Kremling, 2017). Previous studies show how those students with a high level of participation inevitably assume greater responsibility in the advancement of knowledge (Soliman, Costa & Scardamalia, 2021). However, positive conditions in the KB environment (i.e. supportive teaching style, peer support, etc.) can favor obtaining benefits even for students with a lower level of engagement.

Major Goals: Analyze the different levels of engagement perceived by higher education students in the Knowledge Building context.

How the research addresses the issue/problem: Over the span of 16 weeks students worked in KF to advance collective understanding around topics on educational research. Participants were 12 undergraduates enrolled in the subject of educational research, part of a second-year social science degree program at the University of Granada (Spain). Students were divided into two focus groups. The first group (FG1) were learners that had a low academic performance. The second group (FG2) were students that had a high academic performance. Both discussions aimed at knowing their perception about the KB pedagogy and their participation in the learning community. Grounded Theory was applied to analyze students' experience with the Knowledge Building pedagogy.

Advances–what has been learned to-date: This research has allowed us to better understand the different levels of engagement of students in the classroom and recognize the resistance they may present when working according to KB principles. According to the resistances perceived by FG1 members assure that most of the time they were more concerned about quantity than about the quality of notes. Likewise, they claim they avoided assuming the CCR and participating in the constructive discourse. They demanded continuous external professor approval. In addition, they encountered difficulties at working with authentic problems. They assumed that their passive attitude

hindered group cohesion. These resistances were diminishing as the academic year progressed, especially since they carried out the second Rise-Above. For its part, the FG2 students showed a proactive attitude that allowed them to appropriate the KB principles earlier. They perceive having had a high level of engagement with the KB. Despite the difficulties encountered during the learning process, both groups recognize an improvement regarding their educational research skills and a conceptual change according to the content. Still, FG2 students state these more clearly.

Next steps: Future lines of research are aimed at investigating how to engage those students who have a less proactive attitude in the learning process.

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Teacher education student working with idea to improve TPACK

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Statement of the issue/problem: Technological pedagogical and content knowledge (TPACK) is deemed essential for teacher education students. In Taiwan, the predominant approach to developing prospective teachers' TPACK remains to be a top-down, knowledge-telling process.

Major Goals: [what you hope to achieve/accomplish] A bottom-up, design-oriented, knowledge-building process was introduced to helping teacher-education students develop effective TPACK and related 21st century skills (such as collaboration and community-building skills).

How the research addresses the issue/problem: We provided Knowledge Forum (KF) for the participants to work creatively with ideas in small groups in which they used relevant TPACK learned to design an online interface needed for an online lesson. We conducted a pre-and-post TPACK survey for all students, and analyzed groups' idea-improvement processes for advancing TPACK.

Advances–what has been learned to-date: Table 1 showed significant increase of TPACK among all participants; Figure 1 shows how students of one group worked creatively with 24 ideas for gradual improvement in a group discussion thread. The process went by initially producing many diverse ideas to address the target design problem, then selecting certain ideas for further clarification and elaboration, and finally integrating a few promising ideas for use in the lesson design. The results showed that the idea improvement process contributed mostly to the development of TCK only and there is still room for developing students' higher TPACK.

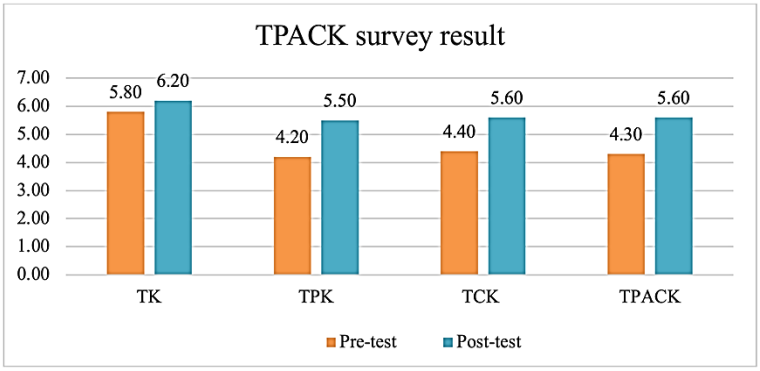

Figure 1. The result of survey regard teacher education's TPACK

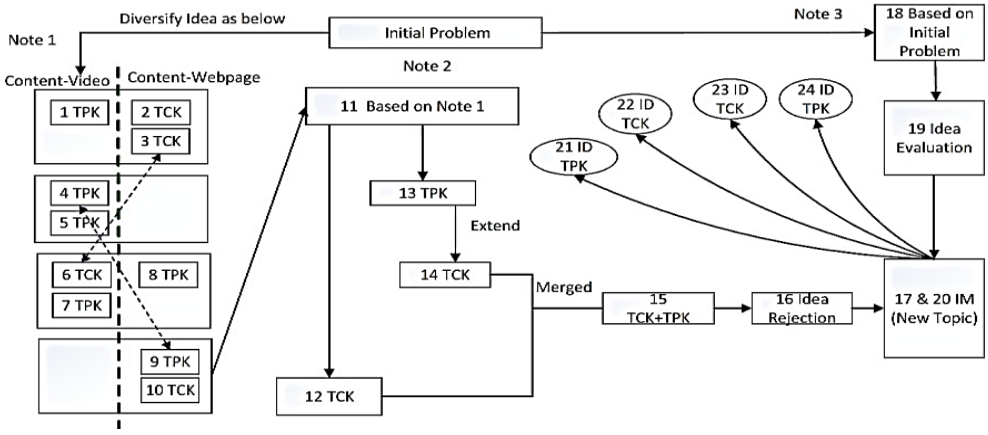

Figure 2. Flow chart of idea's development regarding TPACK dimension

Next steps: At this stage, we only analyzed one of the group discussion threads. The next steps will try to parse all notes into ideas for more complex analyses of idea improvement processes relating students' TPACK development.

Intangible Cultural Heritage (paper-cut) Course Design Based on Knowledge Building Theory

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Research Summary

In this study, an intangible cultural heritage course was designed according to 12 principles of knowledge building, and a three-week experiment was completed in a knowledge building(KB) community. In the intangible cultural heritage KB course, students can express their ideas in a safe and comfortable environment, deeply explore in the collision of views and practical operation, constantly improved their views through knowledge building dialogue, and naturally formed community knowledge. The combination of knowledge building theory and intangible cultural heritage course design not only provides a new theoretical idea for intangible cultural heritage course, but also provides a practical path for practical teaching.

Statement of the issue/problem:

1.How to design a reasonable intangible cultural heritage course based on the 12 principles of knowledge building?

2.How to take paper-cut course as an example to carry out specific teaching practice of the designed intangible cultural heritage course, and whether the expected teaching effect can be achieved?

Major Goals:

1.Try to find out the existing problems by analyzing the current situation of intangible cultural heritage course design.

2.The theory of knowledge building is used to reconstruct the design of intangible cultural heritage courses, and the theoretical model of intangible cultural heritage course design supported by the theory of knowledge building is completed through continuous iteration.

3.Carry out actual classroom teaching with paper cutting as the theme, and form intangible cultural heritage course cases knowledge building theory.

How the research addresses the issue/problem:

On the basis of paper-cutting course design, a three-week experiment was conducted. The study participants were all the students of paper-cutting club of a higher vocational college in Nanjing. There are about 15 girls in total, aged 15-16, all volunteered to participate in the paper-cutting club activities of their own volition. The specific process is as follows:

1. Create problem situation. Guide the students to observe the paper-cut works around them, such as paper-cut for window decoration. At the same time, the teacher provides several mature paper-cut works for students to observe carefully, thus triggering students to think.

2. Express opinions and questions. After observing and thinking teacher encourages everyone to express their opinions freely and write them down on paper. Students who put forward similar questions form a research group to discuss.

3. Practice promotes idea improvement. Do paper cutting to verify your guess or find new ideas through practice. In addition, students can also use their creativity to create a variety of paper-cut works as periodic artifacts. The feature of the paper-cutting course is : the theoretical exploration and hands-on practice closely combined. Students can complete the idea improvement through the alternation of practice and the theory exploration.

Advances–what has been learned to-date:

The changes of students are reflected in the following three points:

1.The students' enthusiasm for learning paper-cutting has been aroused.

2. The depth of the problem raised by students has been strengthened.

3. Students have been able to work together in class.

Therefore, intangible cultural heritage courses knowledge building theory can promote the development of students' innovative thinking and ability. It also provides a basis for further research.

Next steps:

On the basis of this research, the specific teaching practice process can be further completed in the future, and the theoretical model can be improved through continuous iteration. In addition, the concept of knowledge building can also be used for other intangible cultural heritage projects, such as carpentry, cloth art, weaving and so on.

Design for Emergence: Conceptual and Technology Support for Student-Driven Knowledge Building

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Abstract: Design for Emergence echoes the urgent need in learning environment design in the new era when new challenges and dynamics are constantly emerging in the world. Students need similar dynamic and expansive learning environments to be more adaptive and creative learners who can adjust to the ever-changing contexts. However, the current classroom design may not widely reflect these urgent needs. In this poster, we discuss the potentials and challenges of using the design for emergence approach. We argue that the benefits of the design for emergence from the dynamics and fluidity of the classroom structure that fulfils students' evolving needs and interests in sustaining their creativity and knowledge building discourse so that teachers can work as a facilitator to co-design student-generated, idea-centred learning environments.

Design for Emergence and Implications in the Classroom

Creative and transformative knowledge building practices require emergent and dynamic classroom designs in which students work as agentic knowledge builders to engage in sustained knowledge practices within a knowledge building community and dynamic collaboration across different communities.

As an option of Design for emergence, our research tested the emergent reflective structuration (RS) approach as a new form of shared regulation within the classroom and designed a new multi-layer interaction approach for cross-community knowledge building. The process is further supported by the Idea Thread Mapper (ITM), a platform that facilitates collaborative knowledge building discourse both within and cross classrooms (Zhang et al, 2018). Our research results indicated students as young as 5th graders can work as epistemic agents to co-construct shared inquiry structures while continually deepening their knowledge in a domain area through agentic moves to expand, deepen, and reframe the knowledge building work of their community (Tao & Zhang, 2018, 2021; Zhang et al., 2018). Reflective structuration provides a socio-epistemic mechanism to translate the core knowledge building principles into the daily flow of classroom actions and activities. With the help of their teacher, students co-generated different forms of shared structures to co-organize unfolding knowledge building practices over time. During this process, students work as epistemic agents to expand, deepen, and reframe the knowledge building of the community. The analysis also suggested that co-configured dynamic inquiry enables productive knowledge building interactions and outcomes. Drawing upon the insights gained from these studies, our team has been upgrading the ITM tool to support dynamic knowledge building practices with learning analytics integrated to provide reflective feedback on emerging inquiry directions, idea progress, and connections (Zhang & Chen, 2019).

While students in each classroom collaborated in their home classes' discourse space to investigate various themes, they generated a reflective Journey of Thinking (JoT) note to share knowledge progress and challenges in a cross-community meta-space. The reflective JoT note, which includes three sections: problems/issues explored, "big ideas" learned so far, and deeper research needed, served as an epistemic boundary object to consolidate emergent knowledge advances in each community and further support cross-community sharing. With a mutual understanding of the knowledge work in the different classrooms, students further engaged in a synchronous cross-community Super Talk to tackle challenging problems of common interests, valuable ideas developed in each classroom community have the opportunity to travel up to a cross-community space for high-level discourse and extending inquiry (Zhang, Yuan, & Bogouslavsky, 2020; Yuan & Zhang, 2019).

Unlike collaborative inquiry with pre-designed structures from teachers or researchers, the reflective structuration (RS) approach provides a new social and temporal mechanism to shape and guide

ongoing collaborative knowledge building that leverages high-level student agency (Tao & Zhang, 2018, 2021; Zhang et al., 2018). We attempted to address the aforementioned challenges by proposing a new approach of multi-layer emergent interaction supported by new technology for cross-classroom collaboration. The innovative design of RS and multi-layer emergent interaction framework aim to further expand the CSCL research to investigate collaborative learning at higher social levels and over longer timescales (Chen, Håklev, & Rosé, 2021; Stahl, 2013). Our studies examined student collaboration within and across classroom communities that work together to address ever-deepening problems of inquiry with the conceptual and technical support for student-driven collaborative inquiry in a set of Grade 5 science classrooms.

Conclusion

Our research shows that, with the help from their teacher, students in upper elementary grades can implement the RS approach in broader Knowledge Building communities. Research findings also elaborate the processes of cross-community knowledge building using a multi-layer emergent interaction approach supported by ITM, a tool designed to co-organize the unfolding inquiry process over time, monitor emergent directions, and foster cross-classroom interactions (Zhang & Chen, 2019; Zhang, 2018 et al.). We argue for the value of designing for the emergence and implications in the classroom that facilitates students' knowledge building discourse within and across communities. We conclude that the actual needs of sustaining students' inquiry do not lie in merely covering a pre-designed curriculum but in co-designing the learning trajectory with students so that their genuine inquiry and discourse can be sustained.

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Towards Teaching Thinking to L2 Academic Writers

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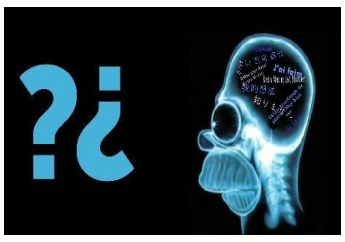


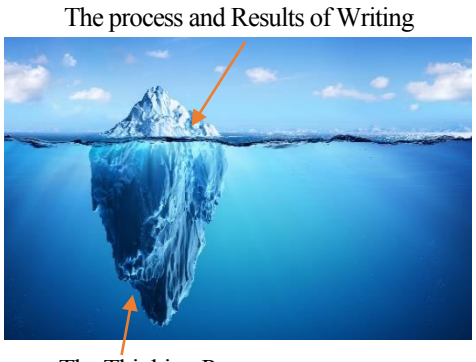
CHALLENGE: THINKING IN L2

Like computational and other specialized thinking in Knowledge Building, success in academic writing relies on both a higher level of cognition and a higher level of craft skills. For L2 learners, an additional skill is required - the ability to think in L2, because otherwise writing will be less spontaneous and more time-consuming when writers try to link their ideas to expressions in a language less familiar to them, and effective delivery will be limited due to writers' inability or lack of control of the target language.

Poor decisions made in the thinking stage lead to misplaced focus or even miscommunication, yet it has not received its due attention in L2 education, mostly because it is considered an internal activity performed by each individual writer, and is therefore elusive and unteachable. On the contrary, the teaching and learning of L2 academic writing stays mostly on the shallow aspects of language, such as the appropriate choice of vocabulary, the ability to vary sentence structures, the proper use of rhetoric, and etc.

This design, however, focuses on the thinking stage of L2 academic writing. The researcher attempts to build up a systematic approach towards teaching thinking skills to L2 academic writers by taking nourishment from Knowledge Building (KB) theory, which is a science on thinking. The goals are double folded: **1. To discover and build strategies/mechanisms that facilitate L2 writers' idea generation, organization and mediation at the thinking stage; 2. To investigate and obtain a deeper understanding of idea dynamics in academic writing.**

The process and Results of Writing



The Thinking Process

DESIGN IDEAS

1. Create Scaffolds to Facilitate L2 Writers' Idea Movement

- What is this?
- How do we make a desk?
- What is a desk for?
- What is a desk?
- How does a desk work?
- What are the differences between a desk and a table?

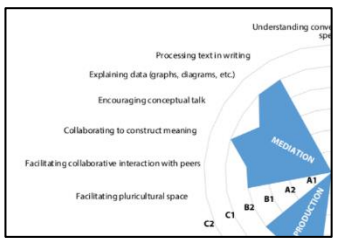
The questions on the left are about an ordinary, everyday life object - a desk, but they require different cognitive abilities from L2 learners. For example, "What is a desk?" may pose a higher amount of cognitive load to L2 learners because it involves *definition*, a higher order of thinking than simply naming an object – "What is this? It's a desk." Yet in L2 education, these questions are often treated in the same way, and as a result, learners tend to blame lack of vocabulary for difficulties they encounter in language learning.

Scaffolds can be developed to facilitate writers to move their ideas from shallow to deeper levels. Useful sources include the seven "good moves" (Bereiter and Scardamalia, 2016) in knowledge-creating discourse, namely, *problem definition, new ideas, promisingness evaluation, meta-dialogue, comparison, critical discourse, and higher-level ideas* can be used for the creation of scaffolds. Another authoritative source for scaffold building is the latest version of Common European Framework of Reference For Languages (CEFR), which places communicative activities into four categories of *Reception*, *Production*, *Interaction* and *Mediation.* The chapter about *Mediation* is particularly useful with its detailed and thorough illustration of mediation activities and strategies that are used by L2 learners of different proficiencies.

2. Create KB Community to Facilitate L2 Writers' Idea Growth

Knowledge Building supports learners to "think like a specialist" (Bereiter, 2020) by demonstrating what knowledge crafting is like and scaffolding writers' writing practice. When placed in the immersive environment of a KB community, L2 writers receive authentic feedback from real readers and their ideas gain vitality with room to grow and flow; and thus, writing transforms from an internal, individualized activity of self-expression to an interactive process towards a common goal of advancing for public good. Future efforts will be invested **in exploring and designing community norms and dynamics that encourage L2 writers to present their ideas**.

3. Create Visualization of Thinking to Facilitate L2 Writers' Self-Assessment



Source: CEFR Companion Volume

The design idea is based on WYSIWYG, a computing acronym for What You See Is What You Get, that allows content to be edited in a form that resembles its appearance when printed or displayed as a finished product (Oxford English Dictionary). The researcher assumes **visualization of the thinking process** will have a similar effect to WYSIWYG, and by allowing L2 writers to produce Concurrent, Embedded and Transformative Assessment of their writing, they will have higher level of agency in mediating their ideas towards a higher-level goal of Knowledge Building. Learning analytics available on Knowledge Forum (KF) are useful in creating the visualization. The researcher also plans to investigate existing writing assistants or tools (such as Grammarly and Readability Checker more) to prototype the visualization.

Next Step

To keep building information on L2 academic writing and Knowledge Building Theory and Pedagogy and honing the design ideas.

Currently, I will focus on clarifying my design ideas and formulating my research questions.

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INNOVATIVE FORMAT

Learning Analytics Goes to School: Shifting the Paradigm from Student-Centered Design to Student-Led Design

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Abstract: In recent years, there has been growing recognition that learning analytics should be co-designed, tested, and refined with educational stakeholders, yet the role of end users, such as students, is almost entirely absent from such design initiatives. This two-part workshop aims to shift the current paradigm from student-centered design to student-led design, drawing from user insights and user innovations in the field to advance next-generation analytics for knowledge creation. Students will work directly with educators, researchers, and engineers in the global community to develop more powerful tools that can be customized across a broad range of educational contexts. An international panel of experts will consider promising directions for work at the intersect of theory, pedagogy, and technology, as well as discuss opportunities to open up new areas of exploration, including the initiation of a series of student-led and teacher-led micro-interventions to be tested across global hubs of innovation before KBSI2022.

Introduction

Over the last two decades, learning analytics has emerged as an important research strand across multiple fields to unpack the complex dynamics of learning (Rosé, 2018). Simply defined, learning analytics involves "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs… It could be thought of as the practice of mining institutional data to produce 'actionable intelligence.'" (Siemens & Long, 2011). More recently, there is growing recognition that these new assessment tools and methods should be co-designed, tested, and refined with educational stakeholders in live educational settings. For example, the book "Learning Analytics Goes to School" (2018) highlights multiple initiatives in K-12 and postsecondary contexts that use data-intensive research methods to improve teaching and learning. However, the role of students in the planning and implementation of these initiatives is almost entirely absent. That is, while instructional decisions are made based on student-generated data (e.g., attendance, task completion, social interactions, and other behavioural/physiological indicators), students remain as mere recipients of these instructional interventions.

In this workshop, we are taking an alternative approach to bringing learning analytics to school by repositioning students as agents in the design of learning analytics. From this perspective, it is not only an ethical obligation to provide students with access and transparency in their use of learning analytics (Prinsloo & Slade, 2017), but it is also a moral obligation to empower students as informed decision-makers and stewards of their own data. The basic premise from which we are working is that educational institutions should support students' movement toward higher levels of agency over their own learning (Scardamalia & Bereiter, 1991). Therefore, the most direct way to cultivate these new dispositions is by engaging students in the re-design of learning analytics in computer-supported collaborative learning environments. As Chen and Zhang (2016) elaborate, next-generation learning analytics – analytics that advance knowledge creation in education – should be agency-driven, choice-based, and progress-oriented in order to facilitate design mode thinking for continual idea improvement. Guided by the principles of Knowledge Building (Scardamalia, 2002) and user innovation (von Hippel, 2005), we aim to shift the current paradigm from student-centered design to student-led design.

It can be said that in almost any field, a large portion of innovations are consistently created by users (Baldwin & von Hippel, 2011). It is users who find ways to tweak specific features, functions, and attributes of

products to suit their specific needs – needs of which manufacturers are often unaware. Examples range from leisure tools such as skateboards to professional tools such as medical imaging devices. As an extension of this view, one can assume that teachers and students are also developing user innovations in their day-to-day practices with analytic tools unbeknownst to learning scientists and engineers. A glimmer of young students' potential as user innovators was seen during the KBSI2019 conference, when grade 6 students (12-year-olds) taught grade 3 students (9-year-olds) different strategies for using the Knowledge Forum analytic tools to reflect on their discourse (see Table 1 in Ma, Akyea, & Martin, 2020). This metadiscourse session was largely student-led. It was through the collective reflection that students came up with new strategies for using the tools to improve their learning and online interactions. While the students did not end up coding new analytic tools, researchers can learn from students' creative strategies – strategies that directly enabled metacognition and intentional learning in less obvious ways. This type of unlikely collaboration between students and researchers hold much promise for transforming existing approaches to conceptualizing, testing, and refining analytic tools, with direct impacts on the design of more powerful learning environments that facilitate knowledge creation in education.

Throughout this workshop, we will refer to students as innovators and knowledge creators (Bereiter & Scardamalia, 2010). More specifically, we will build on the work of the KBSI2019 metadiscourse session by engaging the same group of students in longitudinal analyses of their own data (for examples of analytical approaches, see Zhang et al., 2011 and Chen et al., 2015). As students will be entering grade 6 – their final year in elementary school – they will have the opportunity to reflect on the big ideas and conceptual threads that emerged in their Knowledge Forum discourse over the last five years using various analytic tools. In a metadiscourse session facilitated by their teacher, Benjamin Peebles, students will reflect on the evolution of thought in their community and the evolution of their identities as Knowledge Builders. Some questions they will explore together include, "Think about all the ideas you have learned since grade 1… How do all these things relate to one another?", "How have you grown and changed as learners and Knowledge Builders? What advice would you give to younger students?", and "If you were making the decision of what to learn next, what would you decide? What are the bigger ideas that your work is leading toward?". Students will also have the opportunity to work with educators, researchers, and engineers in the global community to develop more powerful tools that can be customized across a broad range of contexts and potentially uncover new competencies for extending their collective zone of proximal development. Thus, the analytics we will explore together will go beyond visualizing the dynamics of individual learning toward visualizing the dynamics of collective knowledge advancement. Below, we provide an overview of the basic Knowledge Forum analytic tools and more advanced tools for metadiscourse, such as Knowledge Building Discourse Explorer and Idea Thread Mapper.

Knowledge Forum Analytics

Knowledge Forum is an online platform designed to augment "knowledge-creating discourse within and between communities and to provide feedback tools that students themselves can use in exercising epistemic agency" (Scardamalia & Bereiter, 2021). Unlike other computer-supported collaborative learning technologies, Knowledge Forum provides multiple entry points and progressive affordances for students to self-organize around idea improvement, so that they may simultaneously generate multiple pathways for learning and intentionally work toward increasing complexity and coherence across diverse perspectives in their community knowledge. Embedded analytic tools are designed to help make emergent dynamics and processes transparent for all so that collective progress can be made. For example, students can annotate promising ideas (Chen et al., 2015; Chen et al., 2019), conduct discourse analyses (Resendes et al., 2015 Hong et al., 2015), reflect on contribution patterns (van Aalst & Chan, 2007; Yang, van Aalst, & Chan, 2021), and identify directions for future work (Tao & Zhang, 2021; Yuan & Zhang, 2019). When multiple tools are used during metadiscourse (e.g., word clouds, scaffold charts, social network analyses, lexical analyses, activity dashboard), students take on more agency in "critically examining the state of their community knowledge, they deconstructed and reconstructed their interaction dynamics and discourse moves in order to operate more powerfully as a community" (Ma et al., 2020; see also Teo et al., in press).

Knowledge Building Discourse Explorer

Knowledge Building Discourse Explorer (KBDeX; Oshima et al., 2012), is a socio-semantic network tool that visualizes network structures among students, Knowledge Forum notes, and keywords in the discourse. The tool produces various network centrality metrics for temporal analysis of community dynamics. KBDeX has been used to support students' engagement in Knowledge Building discourse and metadiscourse. For example, Oshima and colleagues (2017) visualized students' collective knowledge advancement using the transitions of total degree centralities in keyword networks. While Lee and Tan (2017) used degree centralities in discourse networks to identify promising ideas in a Knowledge Building community, Yuan and colleagues (2019) used betweenness

centralities of keyword networks to identify emergent ideas during cross-community collaboration. Students' collective responsibility was also examined by Ma and colleagues (2016; 2017) and Tong and Chan (2019) using betweenness centralities in the student networks and discourse networks. Taken together, KBDeX provides many affordances for re-visualizing Knowledge Forum discourse, with recent work by Feng and colleagues (2020) showing that students as young as 10 years of age can easily work with these complex visuals to deepen their metadiscourse.

Idea Thread Mapper

Idea Thread Mapper (ITM; Zhang et al., 2018) is a timeline-based collective knowledge mapping tool that facilitates multi-layer visualizations of Knowledge Forum discourse and enables students to co-organize their Knowledge Building process as it unfolds over time. Students can make explicit connections between notes within and across Knowledge Forum communities and monitor emergent themes for symmetric knowledge advancement. ITM has been used to support students' reflective structuration and boundary crossing between Knowledge Building communities. For example, Tao and Zhang (2018; 2021) examined students' epistemic agency in co-constructing shared inquiry structures that deepened Knowledge Building discourse and supported community knowledge advancement. Yuan and Zhang (2019) explored how "super notes" could be used as epistemic boundary objects to facilitate rise above discussions and extend idea interactions across communities. Follow-up interviews with 10- and 11-year-olds conducted by Zhang and colleagues (2020) indicated that students found value in synthesizing their ideas in accessible ways and producing knowledge of value for students in other classes. Taken together, ITM serves as a meta-space over Knowledge Forum discourse to bootstrap reflective structuration, boundary crossing, and metadiscourse.

This interactive workshop will be organized as a two-part event. During the first session, students will engage in metadiscourse with teachers and interact with researchers and engineers in design mode to brainstorm how the tools can be improved to support their everyday needs in classrooms (e.g., customizing automated analyses, recursive functions for reducing redundancy, coherence-making tools for reconstructing views, extensions for enhancing accessibility, etc.). During the second session, educators, researchers, and engineers will reflect on their observations from the metadiscourse session with students to continue design discussions surrounding next-generation analytics for metadiscourse, while addressing the most pressing assessment needs of educators working in K-12, postsecondary, and professional contexts. This two-part event will culminate in a strategic planning discussion with the broader international community to consolidate a research agenda for Theme 2 of the Knowledge Building Global Design Experiment, "Knowledge Building Analytics: Exploring Distinctions Between Learning Analytics and Knowledge Building Analytics."

Day 1: Using KF Analytics for Metadiscourse

Students will work with KBDeX experts Dr. Xueqi Feng and Dr. Yuyao Tong to explore the temporal dynamics of community knowledge advancement across each year. A glossary of keywords from the Ontario Ministry of Education (2007) will be tested and refined to visualize keyword networks in KBDeX, with students analyzing pivotal points in the changing centrality metrics in various keywords to reflect on the process of idea improvement. Students will also reflect on their keyword contributions by exploring their own betweenness centralities in the student networks and discourse networks to identify possible discourse moves that enhanced collective responsibility across each year. Some overarching questions for metadiscourse include: "Which ideas contributed greatest to your understanding?", "What were different strategies you used to help your peers advance their ideas?", "How did you know your theories were getting better?", and "Which idea connections surprised you the most?".

Students will work with ITM experts Dr. Guangji Yuan and Dr. Dan Tao to identify key themes in their community knowledge and co-create their journey of thinking across the five years. Each inquiry thread will be assessed for depth of understanding (e.g., types of questions, explanations, sources) and triangulated against the Next Generation Science Standards' Matrix of Crosscutting Concepts (2011). Students will use crosscutting concepts as different lenses to compare and contrast inquiry threads across the years – to explore knowledge gaps and seek greater coherence in their community knowledge. Some overarching questions for metadiscourse include: "What were some of the biggest ideas you learned?", "Which theories do you think connect across the different areas you've studied?", "Which areas need further exploration? What would you recommend for students working on those problems of understanding?", and "How can your knowledge help us advance our collective goal 'Saving the Planet, Saving Lives'?".

Day 2: (Re-)Designing KF Analytics for Metadiscourse

The second session will start with reflections from an international panel of experts working at the intersect of Knowledge Building theory, pedagogy, and technology across various hubs of innovation. Dr. Bodong Chen will reflect on the state of learning analytics in the KBI community, including significant advances over the last decade, promising directions of current works-in-progress, and possible opportunities to collaborate with other research communities to open up new areas of exploration. Dr. Chew Lee Teo will share her insights integrating theory-driven methods to deepen and sustain metadiscourse and practical strategies that have been developed and tested when Knowledge Forum analytics are put in the hands of students and teachers.

Throughout this panel, experts will make explicit connections between user innovations from their local sites and observations from the metadiscourse session with the grade 6 students. More specifically, Dr. Jun Oshima and Dr. Yoshiaki Matsuzawa – the co-creators of KBDeX – will share their reflections on the main purposes of KBDeX and different ways that KBDeX can be used to support metadiscourse. Dr. Jianwei Zhang and Dr. Mei-Hwa Chen – the co-creators of ITM – will share their reflections on the main purposes of ITM and different ways that ITM can be used to support metadiscourse. Some overarching questions for the panel to pursue include: "What types of reflection was your tool designed to facilitate?", "What metacognitive processes did you notice students were engaged in? Which strategies surprised you?", "What are some underused features that have potential to deepen metadiscourse?", and "What are some new features that might arise from students' suggestions for improvement?".

The discussion around next-generation analytics for metadiscourse will begin with a re-examination of design ideas elaborated at the 2021 Knowledge Forum Thinktank in light of students' epistemic agency during the metadiscourse session. These design ideas will be refined to create playable analytics that tap into students' creativity and ultimately reframe the Knowledge Forum dashboard as an expansive design space that helps users co-create alignments between different user innovations and ever-deepening principles-based practices. The following are key issues raised to advance knowledge-creating analytics for the global design experiment. We expect to further elaborate these issues through audience engagement with the panel discussion to rise above tensions between past, present, and future needs of knowledge creators working at the cutting edge of local and global innovation networks:

- How can the Knowledge Forum dashboard be designed to help users visualize the Knowledge Building principles as a dynamic, interactive, expansive system? How can Knowledge Forum analytics be designed in ways that allow users to easily tweak them and generate new principles-based practices? How can the KF manual be designed as a living document that facilitates ease of use and ease of interpretation for beginners and novices?
- How can we design customizable contribution profiles that are multi-faceted and multi-layered and that allow users to toggle between individual and collective dynamics? What types of theoretical advances are needed to alleviate tensions between existing approaches to assessing individuals and groups (e.g., complex visuals that maintain heterogeneity at the individual level and offer different ways to re-organize, re-integrate, and re-unify at the group level)?
- What are different ways we can approach the conceptualization of productive work with diverse ideas, perspectives, and resources (e.g., transliteracy, multivocality analyses)? How can we design advanced literacy measures that integrate open-ended design mode scaffolds and evolving semantic spaces of different communities? How can core-periphery analyses help users intentionally bring near and far neighbours in conversation to enhance resilience within and across communities?
- How can we identify and be alerted of ideas and theories that students really care about, including ones that are not as popular among their peers (e.g., emotional valence, epistemic uncertainty)? What type of theoretical advances are needed to create measures that go beyond behavioural/physiological indicators of student data and enhance socio-cognitive-emotional coherence of student experiences?
- How can we work with educators to unpack assumptions of linear progressions and reconceptualize assessment approaches toward judging the potentiality of emergent socio-cognitive-emotional dynamics and novel competencies for knowledge creation (i.e., looking at the same data in new ways, looking in new places to find what they are not looking for, strategies for scaffolding open-ended metadiscourse)? What could we consider as heuristics for assessing progress (i.e., an intentional mindset for surpassing ourselves) with the understanding that progress is a non-uniform, non-linear process that might look different across different contexts?
- How do we integrate the latest advances in human-computer interaction (e.g., universal design, accessibility, inclusive design), virtual/augmented reality, machine learning, edge computing, cybersecurity mesh, and semantic web technologies to forge new directions for knowledge-

creating analytics? What role(s) might artificial intelligence play in knowledge creation? How can these technologies be used to systematically reduce inequities and close digital divides in ways that ultimately empower users to lead the next paradigm shift?

This session will conclude with plans to enact a scalable and sustainable infrastructure to coordinate design-based implementation research initiatives (Fishman & Penuel, 2018), perhaps even setting a timeline for a series of student-led and teacher-led micro-interventions to be tested across global hubs of innovation before KBSI2022.

Significance of the Workshop for the KBI Community

In recent years, learning analytics has had a growing presence at KBSI meetings (e.g., Chen et al., 2018; Teo et al., 2018; KF Hackathon, 2019). In addition to synthesizing long-term research initiatives in the global community, this workshop aims to seek synergies across initiatives to chart new directions for collective advances – socio-technological, developmental, and conceptual advances that directly contribute to the Knowledge Building Global Design Experiment.

Longitudinal research in education is rare, but not unheard of. Studies in educational data mining are beginning to uncover learning trends with large cross-sectional datasets. To our knowledge, having a cohort of grade 6 students (12-year-olds) assess their own online discourse over their first five years of schooling is an avant-garde notion in the fields of learning analytics and learning sciences. To further that, researchers will be using advanced analytic tools in novel ways to conduct longitudinal analyses and ultimately return agency back to students so that they can triangulate their findings and unbox the blackbox effect together. This session, thus, offers us the potential to explore new methodologies for analyzing complex, rich datasets and new ways to think about, design for, and refine metadiscourse processes and tools with our community. In addition to the immense research value this session presents, it will serve as a unique professional development activity for teachers to engage in collaborative design with students, researchers, and engineers. Lastly, this innovative format will serve as a testbed for collaboratory designs that enable longitudinal, interdisciplinary, and multivocality analyses of discourse data by gathering input from members of the global community – students, teachers, researchers, and engineers. It is through this rich array of interactions where we can begin to envision new competencies for knowledge creation, while exploring new forms of social configurations in the global innovation network to sustain symmetric knowledge advancement (Hong, Zhang, & Scardamalia, 2010) – challenges which are inherently more of a social than technological nature. Within the context of bringing learning analytics to school, we are actively reshaping the paradigm of schooling in the Knowledge Age based on principles of open collaborative innovation (Baldwin & von Hippel, 2011). It is our hope that in recognizing students as user innovators and collaborators for our own work, we are helping them own their responsibility to advance knowledge for public good.

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