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Collaborative Mobile Learning in Situ from Knowledge Building Perspectives

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In this paper, we present and discuss our implementation path of the design-based research toward fostering collaborative knowledge building culture in the context of teaching and learning integrated humanities in a Singapore secondary school. Specifically, we focus on the design and enactment of two mobile learning trails and related activities in and out of school contexts that aim to scaffold students toward explicit idea sharing and productive discussion in authentic learning contexts. The design of the first mobile learning trail serves as a platform to acquaint students with collaborative learning in situ: idea generation and improvement. In the second learning trail, we provided more scaffolding to help students engage in intentional, continuous and pervasive knowledge building discourse and activities. Data sources include online surveys, focus group interviews, and teacher's anecdotal reflections. Overall, we found that students appreciate opportunities for collaborative mobile learning in situ leveraging on the affordances of the physical environment and mobile technologies. However, we also found that while students hold positive perspectives toward collaborative knowledge building, their actual mode of learning is more cooperative than collaborative, indicating some conflicts between their espoused beliefs and beliefs in action. In conclusion, we argue that promoting a culture of collaborative knowledge building amongst Singapore students requires the "careful orchestration" of lesson design, lesson implementation and appropriation of relevant devices and applications.

INTRODUCTION

The field of learning sciences is characterized by its interdisciplinary nature that examines teaching and learning "to better understand the cognitive and social processes that results in the most effective learning, and to use this knowledge to redesign classrooms and other learning environments so that people learn more deeply and effectively". (Sawyer, 2006, p. xi). While what constitutes the notion of effectiveness and deeper learning remains debatable (depending on the disciplinary, epistemological, and methodological stance underlying research design), the explicit emphasis of the field as a "design science" has distinguished it from other fields in that the claims of the latter remain at the theoretical level with little practical value. As a design science, the field aims to advance both theory and practice through the progressive refinement of design and its impact on the natural contexts of teaching and learning. Rather than controlling and excluding naturally occurring variables, learning sciences researchers study a complexity of natural contexts and make rich accounts of a theory-in-context (Barab, 2006).

Given that the community of learning sciences includes researchers from multiple disciplines, the field is also fraught with diverse views on epistemology and methodology to unpack

human learning. Since the socio-cultural work by Lave and Wenger (1991) on situated learning and the conception of situated cognition by Brown, Collins, and Duguid (1989), one of the influential approaches to the study of learning in the learning sciences community is a situated view where the nature of knowledge and knowing is understood as an enculturation process to participate in authentic practices beyond abstract knowledge. From the situated view, collaborative knowledge building (Scardamalia & Bereiter, 1991) or group cognition (Stahl, 2006) is a mechanism to understand learning in social contexts: emphasizing a shift of focus from the individual to collaborative meaning making in group or community settings.

Employing the situative lens to position learning as enculturation, we present and discuss a design-based research study conducted in Singapore where the aim is to cultivate collaborative knowledge building practices in the context of learning integrated humanities (i.e., history and geography). Pedagogically, we employ the principles of knowledge building that emphasize the continuous improvement of ideas with a belief that "what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts" (Scardamalia & Bereiter, 2003, p.1370). In particular, this paper focuses on the issues and challenges that are likely to surface in the initial process of fostering knowledge building culture, such as: "how to introduce a knowledge building pedagogy into classrooms" and "what are the students' initial perceptions toward collaborative knowledge building experiences that require explicit idea sharing and inquiry process". Further, we explore knowledge building practices from situated learning perspectives by incorporating the affordances of mobile technology and in situ collaboration as significant instruments and channels for knowledge building. Our view on knowledge building as enculturation and in situ collaboration is consistent with the position put forth by Brown and Adler (2008), where they likened the need to assimilate students into the process of "learning to be" to Dewey's concept of "productive inquiry process of seeking the knowledge when it is needed in order to carry out a particular situated task" (p.20). Hence, two fundamental features – "a design focus and assessment of critical design elements" (Collins, Joseph, & Bielaczyc, 2004, p.22) forms the guiding framework in our iterative process of implementation, reflection and refinement of the research presented in this paper.

THEORETICAL BACKGROUND

Knowledge Building as Enculturation

Previous research on knowledge building has emphasized the importance of the enculturation process (Bielaczyc & Ow, 2007; Kolodner et al., 2003; van Aalst & Truong, 2011). The enculturation process into knowledge building culture is a complex endeavor, which necessitates a shift of both teachers and students' epistemologies on the nature of knowledge and knowing. In the context of the Asian-Pacific research community, knowledge building approaches have been examined to promote a shift in the classroom culture of teaching and learning from teacher-centered to student-centered and from task-focused to understanding-focused pedagogies (e.g., van Aalst & Chan, 2007; Oshima, Oshima, Murayama, Inagaki, Takenaka, Yamamoto, Yamaguchi, & Nakayama, 2006; So, Seah, & Toh-Heng, 2010).

The principles of knowledge building (Scardamalia, 2002) have served as a useful measure to attest the essence of knowledge building pedagogies, and at the same time, allow some flexibility for localization and adaptation. In spite of guiding principles, however, teachers who attempt to introduce and promote knowledge building pedagogies in Asian school contexts may face challenges to transform classroom culture from knowledge telling to knowledge building practices; from task-oriented to idea-oriented in the delivery of content. Moreover, teachers may question whether such pedagogical approaches that promote student agency and constructivistic thinking, can work for the academically lower-achieving students. While one of our previous research studies found the compelling evidence that knowledge building pedagogies are beneficial to both higher-achieving and lower-achieving students (So et al., 2010), our interaction with Singapore teachers

indicates that such a concern regarding student ability levels and constructivist approaches is still prevalent.

Another important aspect on fostering a knowledge building culture is the need for an epistemological shift to view a classroom not as a mere collection of individual students, but rather as a collaborative knowledge creation community. However, since much of contemporary school culture, especially in Asian schools, is based on individual performance and assessment, promoting such collective cognitive responsibility has been a challenging task that necessitates gradual scaffolding toward a long-term trajectory. Simply put, we contend that the culture of playing with ideas and messing around ideas is not readily accepted and assimilated into classroom culture. This issue becomes more problematic in the Asia-Pacific context where individual performance and competition for preparing high-stakes national examinations are highly prevalent. Previously, we found that the discourse of Singapore primary classrooms, despite our effort to integrate a knowledge building pedagogy, is still dominated by the teacher-initiated IRE (Initiate - Response - Evaluate) pattern, and student-initiated questioning; while knowledge-centered questions rarely appear (Lossman & So, 2010).

A last and more practical issue for promoting pervasive knowledge building practices is that the access and use of the Knowledge Forum application, which is a vital public space for community knowledge building, has been limited to desktop computer centered environments in school contexts. Platforms for community knowledge building can be extended and enhanced with the integration and adoption of more advanced web and mobile technologies to promote a pervasive culture of knowledge building in and out of school.

Collaborative Knowledge Building in situ with Mobile Technology

The aforementioned issues and challenges that we have faced in our research trajectory of promoting knowledge building pedagogies in Singapore contexts have motivated us to look for ways to address such issues. One approach that we perceived to be promising was to introduce the affordances of mobile technology and web-based applications in order to help students engage in "pervasive knowledge building practices" across physical contexts and time scales. Recent research studies on mobile learning also exemplified the mediation of mobile devices and online learning mechanisms to enhance individual and collaborative learning effectiveness in a real-world setting. For instance, Squire and Klopfer (2007) present the design and enactment of the handheld augmented reality simulations that allow students to engage in both virtual and real contexts of science investigations. They found that the augmented reality simulations provided an opportunity for collaborative narratives that students were engaged in simulating themselves into the practices of real science investigation and had situated experiences about the complexity behind the inquiry process in real contexts.

Another study on collaborative mobile learning is about the use of the Concept Map-oriented Mindtool for Collaborative U-learning (CMMCUL) to enhance learning motivation and achievements (Huang, Shi, & Chu, 2010). The research findings showed that leveraging on the collaborative Mindtool, students were not only able to illustrate the relationships between concepts efficiently in the concept map, but also, strengthen their collaborative mobile learning experience. A related study was also undertaken by Hwang, Chu, Lin and Tsai (2011) where the research team assumed a knowledge engineering approach in the development of Mindtools, MUKS (Mindtool for Ubiquitous Knowledge Sharing) to promote a "grid-based knowledge acquisition" approach. This has proven to have effectively fostered learners' ability to interpret, classify and analyse information, as well as organise and share knowledge collaboratively in the knowledge-sharing interface, as opposed to conventional methods in ubiquitous learning.

Whilst technological mediation plays a definitive role in facilitating the mobile learning experience in the real world environment, we are also interested in the more delicate composites of collective knowledge construction, which forms the quintessence of knowledge building. Hewitt and Scardamalia (1998) emphasize this intricate collaborative learning process as "distributed

cognition" where "each person's individual cognitions are continually reorganized in an effort to construct meaning out of the other person's speech acts" (p.79). We seek to enforce productive discourse towards knowledge building amongst students. Such a learning outcome necessitates both scaffolding strategies as well as the enculturation of knowledge building practices. Technological tools and learning systems alone, cannot achieve this desired outcome.

PURPOSE OF THE PRESENT STUDY

The research program discussed in the remaining part of the present paper is our attempt to extend previous findings on promoting a collaborative knowledge building culture and knowledge building in situ practices. In So, Seow, and Looi (2009), we reported our first attempt to promote so called "knowledge building in situ" practices. We designed the Chinatown learning trail that included six phases of knowledge building from idea generation to idea compare/contrast. Further, the Google Map space was used to allow students to create locative content when they were situated in relevant contexts to plan or revisit their ideas whenever they were connected with mobile devices. We found some compelling evidence that being able to connect across contexts, coupled with students' sense of place, had helped students engage in knowledge-building discourse.

Extending our prior findings on a larger scale and with a focus on design and implementation, the present study examines the impact of the collaborative knowledge building embodied in the design of two mobile learning trails and related activities co-designed by researchers and teachers as part of the design-based research. Our design approach was premised upon a social constructivist approach on educational environments, where students are presented with opportunities to think about the object and subject of study, construct meaning on their own and with others and to apply knowledge in real world contexts (Pena-Shaff & Nicholls, 2004). Figure 1 presents the iterative nature of our study and the variation and refinements made in each implementation from design-based research perspectives. This paper reports findings from two mobile learning trails. Each trail has a different emphasis from knowledge building perspectives. In the first implementation, *Geography Learning Trail in Sentosa*, the emphasis of the mobile learning trail design is to enculturate students into the practices of collaborative learning in-situ. In the second implementation, *History Mobile Learning Trail in and out of School*, we improved the design of the learning trail based on the findings from the first trail to include activities that students can engage in pervasive knowledge building practices in and out of school contexts (more details presented in the section "Design Consideration").

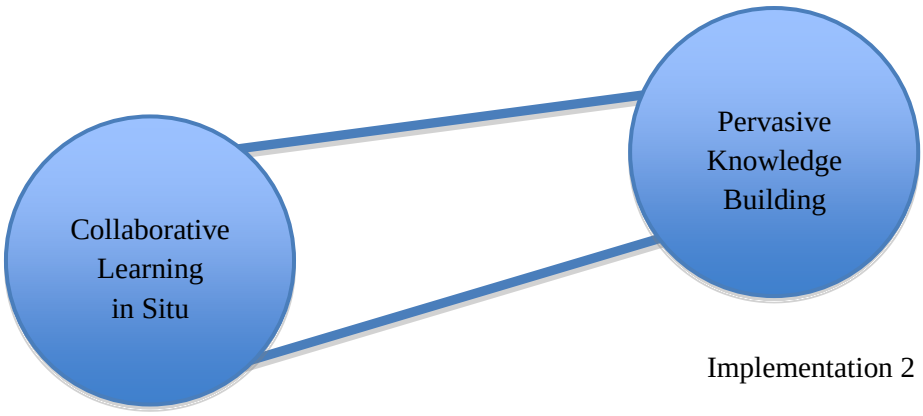

Figure 1: Design Research Trajectory

The succeeding sections of the paper is structured to explicitly show the iterative process of implementation-refinement, and also to address the following specific questions that guided our data collection and analysis process:

- What are the student perceptions of collaborative learning and knowledge building in the initial phase of creating collaborative knowledge building culture?
- How are the student perceptions and experiences toward collaborative knowledge building similar or different in terms of academic abilities?
- What are the students' and teachers' perspectives of engaging and participating in mobile-mediated learning experiences guided by a knowledge building pedagogy?

METHODOLOGY

Research Context

This research was carried out in one of the future schools in Singapore; a forerunner in the use of emerging Interactive Digital Media-based (IDM) tools and mobile technologies for teaching and learning both in and out of the classroom. The school has invested extensively both in human resources, as well as, technological infrastructure, hardware and software to prepare, engage and immerse students in using technology for learning. All staff and students are equipped with MacBooks, and the school campus is fully technology-enabled. One of the hallmark desired student outcomes of the school is to nurture collaborative and independent problem solvers who are motivated, curious and self-reliant and are able to work independently with confidence. This involves enriching and deepening learning experiences via active engagement where teachers facilitate class and group discussions, leading to frequent interaction and feedback between teachers and students, or between students in their groups. Such interaction takes place across online platforms as well as during face-to-face interactions.

In particular for this research study, we closely followed 42 students in two Secondary one (13-year-old) classes in the school. All of them took part in the Geography trail in March 2010, and in the History trail in July 2010. While collaborative learning has been emphasized in the school curriculum, the participating students were not formally introduced to the knowledge building pedagogy before the mobile learning trail. Regarding media literacy skills, students already possessed the requisite skills to handle the technology prior to the mobile learning trail and were well-acquainted with Web 2.0 tools and platforms.

DESIGN CONSIDERATIONS

Premised upon Bereiter's notion of knowledge building – "the creation of knowledge" as "a social product" (2002 in Zhang et al. 2009, p.8) and Scardamalia's (2002) proposition of nurturing "collective cognitive responsibility" (p. 80), two key considerations drive the design and execution of the learning activities for both trails. First, the learning activities should provide students with an authentic platform to apply knowledge in a "real world" setting. Second, the learning activities ought to set the stage for collaborative learning in-situ.

Implementation 1: Geography Mobile Learning Trail at Sentosa

In the first mobile learning trail, the application of geography skills and knowledge transfer were identified as the curriculum foci. Thus the field trip primarily seeks to provide a real world platform for the students to apply geographical skills and knowledge acquired in the classroom and to foster collaborative learning in situ. Sentosa, an island in Singapore, was a choice of the real world platform for the application and transfer of geography skills and knowledge such as navigational skills, mapping and calculating gradient of slopes. The terrain, physical features and

geographical significance in the Sentosa Island make it an excellent platform for students to contextualize their learning experience.

Table 1 presents an overview on the type of tasks and the desired learning outcomes in the first mobile learning trail. Regarding the types of tasks, there is a balance of *performative* and *knowledge generative* tasks in our design. Performative tasks form well-structured tasks where learning paths to complete a task are rather fixed and procedural (e.g., Task 1: measuring and calculating gradients of slopes) whereas knowledge generative tasks are ill-structured with multiple possible answers and provide students with opportunities for generating and improving ideas (e,g, Task 7: design thinking in the Green station). While the curriculum objectives focus on application-based skills and knowledge, we wanted students to situate themselves and "take on" roles of what practitioners such as geographers or scientists would do in real practices, and at the same time, to interact with the environment to generate questions and ideas. In so doing, students would learn to apply these skills across different environments and in various situations. Regarding the technological platform, a web-based application with the Google Map was developed to host the instructions on tasks and student responses.

Table 1. Overview of Task Design at Geography Mobile Learning Trail (see Tan & So, 2011 for further details)

Station	Task type	Description of tasks	Desired learning outcomes
Yellow	Performative	*Task 1:* Measure and calculate the gradient of the slope at 3 different sections of the beach and rank the slope from the gentlest to the steepest.	To understand the impact of physical forces such as erosion and deposition on the steepness of the beach.
	Performative and Knowledge Generative	*Task 2:* Interview tourists to find out why they picked Sentosa as a holiday destination and what they think can be improved for Sentosa as a tourist attraction.	To collect qualitative data through primary resources such as face-to-face interviews for analysis and evaluation of issues.
Red	Performative	*Task 3:* Capture a picture along the coastal area and annotate five physical features: beach, island, observation towers, sea & suspension bridge.	To capture photo images and label its features as part of the process of data collection.
	Performative	*Task 4:* Calculate tower height using trigonometry	To estimate the height of both physical and human features & to relate the actual features seen on ground to the representation on topographical maps.
	Performative	*Task 5:* Identify, capture a picture of the ridge and annotate the physical feature.	To differentiate between physical features.
	Performative and Knowledge Generative	*Task 6:* Identify important industries near Sentosa and state their significance for the Sentosa establishment	To ask geographic questions, acquire and analyse geographic information
Green	Knowledge Generative	*Task 7:* Design thinking with a focus on the beachfront area of the Sentosa island in terms of its attractions, accessibility and	To analyse, synthesize and evaluate real-life situations, in a systematic manner.

		amenities. Identify a problem area and propose solutions, following the four fundamental steps of design thinking – brainstorm, share, categorise and solutioning.	

Implementation 2: History Mobile Learning in and out of School

The history mobile learning forms the next significant platform for the study on the fall of Singapore to the Japanese in World War II. As part of the progressive refinement of design-based research, some improvisations were made to improve the overall trail design and related activities to help students engage in knowledge building discourse in and out of school contexts. First, the history mobile learning trail was designed to anchor continuous and intentional learning experiences. Hence, a pre-trail was phased in to prepare students for the in situ learning experience where students researched on key background information on the four battle sites and generated pre-trail inquiries in their small groups. Similarly, some post-trail activities were designed to help students continuously build knowledge back in the classroom. Table 2 presents the overview of the task design of the history mobile learning from pre-trail to post-trail activities. Second, the trail experiences were more comprehensive this time with two separate visits to four battle sites (two sites per day on the same week). The overarching objective of this trail is to situate learners in the "authentic" sites where the battle for Singapore was fought and where the eventual defeat and surrender happened. Key reflection questions were crafted for each battle site to scaffold idea generation and sharing. The emphasis of the task design was on situating students in the mode of inquiry and reflective learning so that students could generate and improve ideas through the sense of place and rich contextual information available in the sites. Finally, to help students engage in knowledge building discourse both online and face-to-face, Google Site was created for each team, and students were to access the Group Site to enter their findings. The Google Sites were also used for the post-trail, with all task instructions and reflection questions put up for further discussion. Beyond the small group collaboration on the Google Sites platform, an online forum with four broad statements for discussion (e.g., "British defeat at Kranji was an issue of miscommunication".)

Table 2. Overview of Task Design at History Mobile Learning In and Out of School: Pre-trail to Post-trail Activities

Phases	Task type	Description of tasks	Desired learning outcomes
Pre-trail	Inquiry-based	With given lead questions, students are to watch a short clip on the battle for Singapore: *Task 1.* Research, share and discuss information on the four battle sites. *Task 2.* Generate pre-trail inquiries for each of the four battle sites.	To generate investigative inquiries (for actual trail at the four battle sites)

Battle Sites: 1. Kranji 2. Bukit Chandu 3. Labrador Park 4. Ford Factory	Inquiry-based & Reflective Thinking	For each of the battle site - visit the exhibit, display & monuments (textual and artifact sources). Task 3: Affirm earlier findings and respond to inquiries generated during the pre-trail. Task 4: Gather relevant information at the respective battle site and respond to two reflection questions for each battle site.	To appraise content for source reliability To make valid inferences from information and data.
Post-trail	Inferential	Review collated findings and responses to the reflection questions for each of the battle site: *Task 5:* Infer from the collated findings on the battle for Singapore, the deciding factors for victory or defeat in a war. *Task 6:* Identify and evaluate main factors for Japan's swift conquest of Singapore.	To examine and evaluate the various information from multiple sources and make valid interpretations and grounded justifications.

Data Collection Methods

To evaluate the effectiveness of our design, we closely followed two classes with the composition of students of different academic ability levels (Class A: n = 21, Class B: n = 21). Class A included mostly high-achieving (HA) students while Classes B included mixed-ability (MA) students. The selection of the two classes stems from the pedagogical consideration to investigate if academic abilities have any bearing on the ability to participate in, as well as, benefit from knowledge building practices. As shown in Table 3, both quantitative and qualitative data were collected to study the impact of the designed activities on collaborative knowledge building.

Table 3. Overview of Data Collection

	Data Source	Factors	Responses
Geography Trail	Collaborative learning survey	Self-perception Perception of team members Team work Progress Satisfaction	n =39
	Focus group interview		n =12
History Trail	Knowledge building survey	Knowledge building Cooperative learning Learning and discussion	n = 42
	Focus group interview		n =8

Quantitative Data. The collaborative learning survey, adapted from Brown, Eastham, and Ku (2006) contains a total of 31 Likert scale items measuring five factors: (a) self-perception, (b) perception of team members, (c) team work, (d) progress, and (e) satisfaction. Next, in the second implementation, we extended the scope of data collection to better reflect aspects of knowledge building since we had brought in more scaffolding to help students engage in pervasive knowledge building discourse from pre-trail to post-trail lessons. The knowledge building survey with a total of 16 Likert scale items was adapted from the research studies by Shell, Husman, Turner, Cliffel, Nath, and Sweany (2005) and by Yuen (2006). We adopted three constructs important to the purpose of our research: (a) knowledge building; (b) cooperative learning; and (c) learning and discussion.

Qualitative Data. For a more in-depth understanding of student perspectives on collaborative knowledge building and other associated issues, focus group interviews were also conducted after each implementation, with selected students from the two classes to inquire on collaboration efforts before, in and after each mobile learning experience. The selection of students was conducted by means of purposive sampling based on the teachers' recommendation to have a representative sample in terms of academic ability and gender.

The interview was semi-structured with three main constructs, namely, (a) trail design and activities, (b) small group collaborative knowledge building, and (c) technology mediation. In addition to student narratives, we also included teacher narratives as a form of reflection to better identify the issues and challenges that are likely to surface in the initial process of fostering knowledge building culture.

FINDINGS

Student Perceptions about Collaborative Learning and Knowledge Building

The collaborative learning survey was administered after the geography trail. Table 4 presents the factor reliability coefficient, mean values and standard deviation (SD) of different factors for each class. Overall descriptive statistics indicate that the student responses are positive about collaborative learning experiences mediated by mobile technologies. Specifically, relatively high scores were found in the Self-Perception and Team-Perception factors whereas both classes scored lower in the Progress factor. That is, that while most students agreed about individuals' and team members' contribution to the success of the group tasks, some students might not agree with that they had achieved more as a group than working individually. It is interesting to note that overall Class B (MA), in comparison to Class A (HA), shows higher scores in all factors pertaining to collaborative learning. However, independent sample *t*-tests show that there is no significant difference between the two classes for any factor. This may imply that the academic ability level is not a critical factor attributing to the student perceptions about collaborative learning, and both mixed and high ability groups had positive perspectives about their collaborative learning experiences.

Table 4. Descriptive Statistics on Students' Perceptions about Collaborative Learning

		Class A (HA) n =19		Class B (MA) n = 20	
Factors	Cronbach's Alpha	Mean	SD	Mean	SD
Self-perception	.75	4.26	.57	4.47	.58
Team-perception	.93	4.22	.58	4.36	.79
Team work	.75	3.99	.66	4.26	.64
Progress	.85	3.72	.73	3.85	.76
Satisfaction	.88	3.88	.75	4.23	.55

As we adopted a progressive research design approach toward fostering a collaborative knowledge building culture, the knowledge building survey was introduced in the second implementation to assess students' perception of knowledge building practices. As indicated in Table 5, the respondents showed positive perceptions toward knowledge building as all of the mean values are close to or above 4.0. Similar to the findings from the collaborative learning survey, on the whole, Class B (MA) in comparison to Class A (HA), shows higher scores in all factors pertaining to knowledge building. Independent sample t-tests were conducted to examine the mean differences between Classes A and B. The result showed that there was no significant difference between the two classes. Again, we were able to confirm that regardless of the academic ability levels, the participants in the two classes had positive perceptions about knowledge building practices.

Table 5. Descriptive Statistics on Students' Perceptions about Knowledge Building

		Class A (HA) n = 21		Class B (MA) n = 21	
Factors	Cronbach's Alpha	Mean	SD	Mean	SD
Knowledge building	.94	3.95	.49	4.10	.84
Cooperative learning	.92	3.82	.55	3.93	.87
Learning and discussion	.90	3.97	.44	4.02	.84

Student Narratives on Collaborative Mobile Learning in situ and Knowledge Building

At the descriptive level, Class B (MA) seemed to appreciate collaborative knowledge building better than Class A (HA) while statistical tests showed no significant differences between the two classes. This phenomenon would be better understood via focus group interview –a qualitative instrument of measurement and analysis to gain insights into learners' perceptions of collaborative mobile learning and teamwork in the course of undertaking the activities collectively.

On the geography trail, all participants voiced unanimously that the learning experience was refreshing as the activities at each station required them to interact with the environment, and for some students, this had in turn necessitated greater group discussion in order to resolve their group tasks. Students also explained that the nature of the tasks and their immediate connection to real environments created a unique experience of collaborative learning; building on each other's ideas to arrive at a final solution. For instance, Nathan shared on one of the tasks that impressed him most, "using a clinometer and the distance between our position and our target … we can actually find out the height of the tallest tower."

On their first experience about collaborative learning in situ on the geography trail, Casey explained, "The thing is that everyone needs to accept every one else and it has to be focused...accept one another and come to a consensus after everybody else has contributed". Likewise for the history trail, students expressed appreciation of knowledge in situ and knowledge co-construction. Students mentioned that the built-in of the pre- and post-trail phases for the history trail, as tuning-in and follow-up stages respectively, provided more continuity in the learning transition. For the pre and post-trail activities, the duration was deemed appropriate as they were undertaken within curriculum hours. Also, students felt that they were able to manage longer discussions, with fewer interruptions as compared to the outdoor trails.

Theoretically, students showed good understanding of the difference between collaborative and co-operative efforts, but putting it into practice proved to be challenging at times. One student, Wei Tai likened collaboration to "sharing of knowledge" and "team members working together." However, collaboration patterns differ for the two trails. In the geography trail, they were able to work closely as a group at every stage, partly owing to the nature of the location and trail structure; but for the history trail, they had the inclination to apply "divide and conquer" mode in view of the amount of information from the exhibits. They first allocated individual work before coming

together to collate and discuss their findings as Ramesh put it, "is like an army, you are issuing people to various places … sometimes you send more than one to verify the information… but in the end, we come together as one to collaborate and share the knowledge we have found."

On the meaning and value of collaborative learning, students knew the value of group work and expressed appreciation for undertaking different levels of collaborative learning, i.e. within the group and inter-group. Students found that collaboration helped them in their own individual learning process. Both face-to-face and online collaboration were also deemed necessary from the students' perspective. For some of them, they continued with the online collaboration and video conferencing in the evenings, after the trail, to further continue their discussion and organize their final findings.

More specific to knowledge building practices, students' responses to the experience during the trails fall into two distinct categories: one, which they perceived was *knowledge in-situ* and the other was *knowledge co-construction*. Students were pleasantly surprised and pleased with the on-site experience. For the geography trail at Sentosa, measuring the gradient of the slopes and the tower height was considered application of skills in real world contexts. For them, knowledge transfer had occurred when they were "taken from the textbook to the real site" - the contextual information went beyond the book to the actual site. This was particularly so as they recounted the visit to the war tunnels in the Labrador Park and the battlesite for Bukit Chandu. The learning trails had quickened and strengthened their conceptual understanding of the issues taught in class. This learning experience in situ was further heightened and enhanced via knowledge co-construction where the individual knowledge gain was promoted by group contribution. Ramesh shared that "if you are working in groups of four, you get to see four different perspectives which you could never have thought of that before...". Students believed that they had experienced knowledge building practices in the history trail over the two months from pre to post-trail - an improvement of both personal and group knowledge.

As mentioned earlier, another crucial element of learning in situ is the availability and affordances of the mobile device and wireless connection, which enabled them to source information and affirm solutions on the spot. For the geography trail, Nathan commented, "we have more resources to work with: able to use the Google Maps to locate stations and calculate distance to the tower". Farizah underscored the perspective, "at least we get to use the Macbook more, take pictures, learn about features". For the history trail, participants commented that the affordance and control of the devices affected their collaboration especially when the sharing of one device on learning trail is concerned. Students also indicated their preference for reliable and portable devices to collect, archive and retrieve their data and findings for discussion purposes.

Teachers' Narratives on Enculturation and Implementation

In this section, we present narratives by the teacher who was the co-designer of the whole lesson and relevant trail activities. The narratives surfaced some challenges and issues likely to surface in the initial phase of introducing a knowledge building pedagogy. As an instructional leader to the Humanities Department as well as a practitioner in the classroom, she expressed that introducing knowledge building entailed several challenges in her professional portfolio. The first challenge was getting the buy-in from her colleagues to adopt a knowledge building pedagogy in the co-design of the trails and in the implementation of knowledge building in their lessons or classroom delivery. She shared that as knowledge building is a relatively new pedagogy in the Asian educational context, her colleagues were uncertain of its benefits or were concerned whether they would be able to implement it successfully. The traditional Asian classroom had always downplayed the importance of collaborative learning as it is believed to take away precious curriculum time. This may reflect a pervasive belief and real concern among teachers that the same content could have been delivered via rote learning, or 'drill and practice' modes. Moreover, as a new school embarking on the affordances of technology in a 1:1 computing environment, most if

not all of the academic staff, were still struggling with the pervasive use of the learning device in their daily classroom practices.

Collaborative learning from knowledge building perspectives meant that students had to build on one another's ideas in the formative discourse of what was on-going during the lessons, and teachers perceived this as another challenge faced in the implementation process. All of the students had not been formally trained or introduced to collaborative learning, especially when it involved the use of online platforms like a discussion forum. Hence, the teacher's observation indicates that some students tend to deploy the 'division of labour' or 'divide and conquer' mode when they were posed with the group tasks. The manner in which the tasks had been completed did not require much discussion after the groups had internally divided the workload amongst themselves. This could be defined as co-operation, rather than collaborative learning.

In terms of subsequent classroom delivery of the subject matter, the teacher shared that the mobile learning trails certainly saw long-term gains from the practitioner's point of view. For instance, less time was now spent on explaining actual physical conditions at the battle sites visited, since students have had the opportunity to experience for themselves the authentic conditions at the respective sites. Also, students displayed a greater interest in making the connections between what they had seen at the battle sites with the content taught in class. The teacher commented that subject specific skills like the historiography skills of making observations and inferences had been attained by students in the process, as evident by the improvements in their pen and paper assessment scores in the end of year examinations. Incidentally, students remarked on how they were now able to better appreciate being able to live in times of peace, as socio-affective skills like empathy and citizenry ethics had been developed across the visits to the respective battle sites in Singapore.

DISCUSSION AND CONCLUSION

In this paper, we discuss our implementation path toward fostering collaborative knowledge building culture in the context of teaching and learning integrated humanities in a Singapore secondary school. Specifically, we focus on the design and enactment of two mobile learning trails and related activities in and out of school that aim to scaffold students toward explicit idea sharing and productive discussion in authentic learning contexts. We are persuaded that pervasive knowledge building culture emerges when social conditions are conducive to such knowledge creation practices and epistemic views. Further, such learning conditions need to be carefully devised, embedded and fostered from an early stage. From this perspective, the school described in this paper holds much potential for promoting pervasive knowledge building culture since the school is new, its teachers are open to constructivist approaches, deeper understanding is emphasized in all curriculum design, and more importantly collaborative learning is an important skill fostered across all subject areas. In sum, we found the school in a situation with relatively low barriers for introducing and adopting a knowledge building pedagogy.

Employing design-based research as a methodological framework with an aim to identify critical design elements, our design approach was gradual but progressive. That is, we started with fostering more general attitudinal development and skills toward collaborative learning in small group settings, and then moved to bring in more community aspects in the second implementation. Another distinctive feature of our design is to use the affordances of mobile technologies and web applications in order to help students engage in pervasive knowledge building discourse and activities.

Related to the first research question on student perceptions, the data imply that some conflicts may underlie between their *espoused beliefs* and *beliefs in action* in terms of participating in collaborative knowledge building activities. While both the survey and focus group interview generally show that the students have positive perceptions and attitudes toward collaborative knowledge building, the teacher's narratives indicate students' tendency to deploy the cooperative or 'divide and conquer' mode rather than a collaborative mode of learning. This behavioral inclination may be related to students' epistemic views on knowledge and knowing. In the

Singapore context, shifting students' epistemic views becomes more challenging to Secondary One students who just went through an extensive preparation, mostly through the drill-and-practice mode of learning, for the national exam at Primary Six. Bridging espoused beliefs and beliefs in action is a challenging task, and our view is consistent with prior research that emphasized gradual but explicit scaffolding toward the know-how of collaboration and making knowledge building principles more explicit to students (Bielaczyc & Ow, 2007; Kolodner et al., 2003; van Aalst & Chan, 2007; van Aalst & Truong, 2011).

One encouraging finding in this research is that the academic ability level did not appear as a critical factor affecting student perceptions about collaborative learning and knowledge building. At the descriptive level, the mixed ability group appeared to score higher than the higher ability group while statistical testing showed no significant difference between the two groups. Given that both mixed and high ability groups positively perceived knowledge building practices, we contend that another important factor to consider is students' perspectives on collective cognitive responsibility; that is, viewing collaboration as "part of broad cultural efforts" and appreciating "what the community accomplishes will be greater than the sum of individual" (Scardamalia & Bereiter, 2003, p.1370). This issue was evident in their preference for individual as compared to collaborative modes of learning. The other issue of preferred self-directed learning versus the presence of facilitators providing information surfaces a critical element in the area of activity design and implementation, which inevitably impacts the nature of collaboration and the intended culture and type of collaboration we seek to foster. One way to address this issue would be scaffolding students to be more conscious of the nature of activities and requirements, to take greater ownership of their own learning, and to make their ideas more visible to the class community. In addition, teachers can play a more active role in ensuring that students contribute to the formative discourse by modeling, monitoring, and scaffolding student ideas, and co-constructing guidelines with students on how to build on one another's ideas for the advancement of knowledge.

Based on the main findings reported in this paper, we argue that the "space" for collaboration and the type of collaboration evidently vary with design and facilitation, and a "careful orchestration" (Dillenbourg & Jermann, 2010) of activity design and enactment is critical to help students engage in collaborative knowledge building discourse and activities. Facilitation is imperative to stage, to charter and to "frame" the route towards a collaborative knowledge building culture. But facilitation, if not carefully discerned and executed, would unwittingly constrict the learners' capacity to exercise greater independent and reflective thinking in the completion of group tasks. The same goes for the task design, as indicated in the geography trail. The nature of activities has afforded the participants an "independent" platform, wherein they could exercise the liberty to make group decisions with the data at hand.

Some limitations of the present study should be noted. Data presented in this paper are drawn primarily from the mobile learning trails and lesson activities in selected topics, and may not be generalized to other topics or grade levels. In terms of research methods from design-based research perspectives, we believe that there is a need to create more continuous and accurate indicators showing the progression of knowledge building discourse in and out of school contexts. Further, we are aware of the limitation of MacBooks as mobile devices for learning in-situ, and will further explore the affordances of more portable mobile devices and appropriate applications in order to support pervasive knowledge creation practices. Finally, since this research focuses on collaborative aspects of learning in small group settings, student interaction across groups and at the class community level were not fully explored.

Nonetheless, we believe that our findings contributes to the learning sciences research community by presenting our initial attempt to foster pervasive knowledge building culture where "a sense of the spirit of classroom communities in which ideas are at the center, knowledge building is the job, and collective cognitive responsibility is nurtured" (Scardamalia, 2002, p.80). Future

research will focus on documenting and sharing our implementation path with the research community, especially identifying localized issues pertinent to the Asia Pacific context.

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