Leveraging Knowledge Building in Seamless Learning Environments

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Abstract: In this initial study, we explore how recent advances of mobile and web-based technologies can be utilized to support seamless knowledge building processes and to enhance contextualized learning experiences across multiple locations. Using design research as a methodological framework, we analyzed current practices and configurations of mobile learning in one primary school in Singapore, and co-designed a learning scenario with teachers towards seamless knowledge building experiences. The artifacts of a Primary 4 were analyzed to examine the knowledge building processes based on a location-based mobile learning scenario. We conclude by a discussion on both the possibilities and challenges of knowledge building using mobile technology and web-based service mapping service based on our early experiences.

Keywords: knowledge building; mobile learning; web-based mapping service technology; location-based learning

Introduction

This paper examines the potential of seamless learning environments using mobile computing and web-based mapping services as a mediating tool for knowledge building in formal and informal settings. Bereiter and Scardamalia have developed a pedagogical approach called knowledge building that emphasizes the collective cognitive responsibility for advancing knowledge among a community of learners [1]. The essence of knowledge building approaches is 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” [2].

In Singapore, the Learning Sciences Lab has conducted research studies that aimed to transform learning environments to move away from teacher-centered to student-centered pedagogies based on knowledge building approaches. Though findings showed positive outcomes in student learning [3,4,5], we also noticed some challenges and limitations of implementing knowledge building approaches using Knowledge Forum in schools. First, the text-based functions in Knowledge Forum may not be able to support diverse learning styles, especially for those young learners with limited linguistic abilities. For instance, a research study of Primary 3 students [3] found that student notes in Knowledge Forum tended to be short and fragmented with lack of idea diversity and
explanation-seeking questions. This phenomenon could be related to young learners’ lack of linguistic ability to express their ideas and to the difficulty of translating abstract scientific concepts into concrete words. Secondly, the use of Knowledge Forum is often limited in school environments, and students are not continuously engaged in knowledge building activities outside of schools. With such limited access to computers in the school lab, it would be hard to expect pervasive knowledge building. Finally, knowledge building activities in classroom settings are often separated from real contexts. Students are given little opportunities to go out to the fields to directly and physically explore our world.

Given the limited affordances of a desktop–based computing tool, this paper explores how one-to-one mobile technologies can be used to support seamless knowledge building activities in and out of school. Employing a design research as a methodological framework, we aimed to understand both the possibilities and challenges of supporting knowledge building activities using mobile devices. Based on our first analysis, we worked with teachers to redesign a learning scenario towards seamless knowledge building in and out of school. Specially, we explored how the coupling of typological and topological spaces can be designed and implemented to enhance knowledge building using mobile devices and web-based mapping services. In conclusion, we discuss both possibilities and challenges of knowledge building with mobile devices, and directions of future research based on our early experiences.

1. Theoretical Background

1.1 Towards Seamless Knowledge Building

Research on cognition and instruction for the past decades has emphasized the importance of linking learning in the classroom and learning out of school [6,7]. As mentioned earlier, however, most previous research on knowledge building examined formal learning in school contexts, and paid little attention to linking knowledge building in and out of formal and informal settings in a pervasive and seamless way. Recent studies suggest that the gap between formal and informal learning can be bridged by utilizing the affordances of mobile technology. This means new possibilities of knowledge building beyond sitting in front of computers towards active interaction and participation in real contexts. For example, seamless knowledge building using mobile device can support:

- **Increased access and ownership**: Compared to desktop or laptop computers, small, portable, and less disruptive mobile devices could promote increased access to computers across different spaces (both physical and virtual) and time

- **Building knowledge in situ**: One of the critical problems in traditional schooling practices is the excessive amount of decontextualized and abstract information. Using mobile devices, it is possible to conduct read-time data gathering and analysis with little time delay. Such integrated inquiry processes can help students make strong connections between ideas and observations and between abstract and strong knowledge.
• **Artifacts as a mediating tool for knowledge building**: Using multimedia functions supported in mobile devices such as video/audio recording and digital cameras, students can easily create and modify digital artifacts captured in contexts. When these artifacts are integrated to the public space (e.g., web-based Knowledge Forum), they can trigger knowledge co-construction and collaborative discourse among a community of learners.

### 1.2 Linking Typological - Topological Spaces

Another area that we examined in this study is the coupling of typological and topological space. Lemke [8] discusses a distinction between typological and topological representations. While typological representations are language-based and categorical, topological representations are space-based and continuous. Furthermore, Roschelle and Pea [9] argue that there are two ways of leveraging topological space: geospatial mappings based on attributes of the physical world (e.g., GPS, context-aware programs), and semiospatial representations not mappable to spatial attributes of the physical world (e.g., concept mapping tools).

Several researchers have used the environment as a resource of learning using mobile devices. The Savannah project is an example of participatory simulation where children role-play as predators and roam on the field [10]. In this setting, students carry global positioning systems (GPSs) connected to personal digital assistants (PDAs) in order to explore a real play field designed like a virtual savannah. Using their PDAs, students could record specific information and send it to the Den where they reflected on their performance in an indoor space. The Environmental Detectives [11] is an example of augmented reality mobile learning environment requiring students to move to various positions to collect data in contexts and solve an environmental problem. Similarly, in the Ambient woods, mobile devices can be used to help students explore digitally augmented physical environments where contextually relevant information and resources are provided [12]. While these learning environments provide students with the opportunity to interact with the environment with mobile devices, they do not let students deepen their understanding through textual knowledge centered on topological spaces [13].

### 2. Methods

#### 2.1 Research questions

The purpose of this exploratory study is to examine the potential of combining mobile computing and Web 2.0 application to support knowledge building in and out of school. Specifically, we are interested in investigating how to design a learning scenario to support (a) knowledge building in situ, (b) location-based knowledge building discourse, and (c) collaborative meaning-making between students. Primary 4 and 5 students in one primary school in Singapore participated in this study. Employing design research as a methodological framework, we collected data from multiple sources including student interviews, reflections, artifacts, and teacher diaries. Since our focus for this initial study was on the design aspects of mobile learning, we worked with teachers to co-design a
learning scenario based on findings from the initial field trip. Emphasis was placed on the iterative process of design-implementation with repairing strategies for the refinement of knowledge building theory and practices with these emerging technologies [14].

2.2 Research Context

The school has been an early adopter in the use of mobile technologies for learning. They have considerable experience in designing and implementing outdoor mobile learning activities using the Pocket PCs and Palm mobile devices. The school over the past year purchased Ultra Mobile Personal Computers (UMPCs) and subscribed to 3G broadband services. The Chinatown district heritage trail, reported in this study, is their first of UMPC and 3G broadband for outdoor mobile learning. Singapore's Chinatown is a historical site where the first Chinese settlers congregated since the first arrivals in the 1820s. The trail is a whole day event which had several learning objectives: a) to help understand cultural heritage of Chinatown; b) to appreciate the integration of ethnic races which existed in the early days of Singapore; c) to participate in community service by visiting several senior citizens in Chinatown and learning to understand the lives of Singaporeans 50 years ago. The trail was planned, designed and implemented by the teachers with the co-operation of a local community service group which provided tour guides to lead the children in the trail and visit several notable landmarks in the Chinatown district. There were two designs of the learning trail. In the first design, the cohort of Primary 5 students participated in the activity which was carried over a few days. Based on feedback from researchers who participated as observers in the first activity, the teachers made repairing strategies to improve the first learning scenario. Three classes of Primary 4 students participated in the redesigned learning activity with each student equipped with a UMPC with 3G wireless broadband to access Google Maps web-based mapping services during the trail. They used computers in the school lab in the post activity to view and critique information provided by other students. Students continue to engage in the collaborative activity with the use of their home computers after school.

3. The Redesigned Learning Scenario: Location-Based Knowledge Building

3.1 Learning Activities

We introduced repairing strategies for the redesigned activity based on the following guiding principles: 1) engage the students in the environment by leveraging on their sense of place; 2) facilitate collaboration between students to build and share their knowledge based on the places they have visited; and 3) encourage the students in higher order thinking skills to reflect on their learning goals and experience. We used Google Maps as a typological-topological space for students to identify places they visited, mark the locations and enter their ideas based on these location. Students share their map spaces with other students to foster collaboration in and out of school through sharing, exchanging and comparing ideas. As shown in Table 1, the redesigned learning scenario
include six phases from generating initial ideas and guiding queries to sharing and comparing diverse ideas mapped in the Google Maps space (Fig 1).

Table 1. Redesigned learning scenario

<table>
<thead>
<tr>
<th>Phase</th>
<th>Activities</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1 Impressions &amp; Queries</td>
<td>In this phase, transactions take the form of statements and questions. Students input their personal impressions and queries on an online discussion area.</td>
<td>Pre-activity</td>
</tr>
<tr>
<td>Phase 2 Input of content</td>
<td>Students input their basic knowledge content regarding the discussed area. The sources range from the web, books, articles, stories, and recounts from other people and their personal experiences.</td>
<td>Classroom</td>
</tr>
<tr>
<td>Phase 3 Sharing and comparing of information</td>
<td>Students make use of the Google Maps space to share and compare ideas which are varied in nature and of many differences.</td>
<td>Field Trip</td>
</tr>
<tr>
<td>Phase 4 Peer questioning and collaboration</td>
<td>Students become aware of differences in views and interpretations of content. At this stage, they discover possible new content and explore through questioning, clarification, and elaboration.</td>
<td>China Town</td>
</tr>
<tr>
<td>Phase 5 Conciliation &amp; Co-construction of knowledge</td>
<td>There is conciliation of outcomes. Areas of agreement and disagreement are shared on the Google Maps space.</td>
<td>Post-activity</td>
</tr>
<tr>
<td>Phase 6 Revision &amp; changes in perspectives</td>
<td>Students revisit their knowledge initially and gained subsequently. They now have different perspectives to a common topic through sharing ideas with their peers.</td>
<td>Classroom</td>
</tr>
</tbody>
</table>

![Fig 1. Google Maps space in the satellite view that students used to mark the location of places and enter ideas based on location](image)

3.2 Findings
We present major findings from the analysis of student notes in the Google Map space and from student interviews of one P4 class (n=40). Overall, students in this class created 239 location markers on the Google Map space. This works out to about 6 markers per student. Among them, 110 markers were annotated by other students in the form of clarification, new factual information, or additional questions or comments. For in-depth analysis of collaborative knowledge building in location-based learning, we selected examples of student notes that show how this learning space promotes (a) knowledge building discourse, (b) students’ sense of place in contextualized learning, and (c) motivation for collaborative knowledge building.

*Knowledge Building Discourse in the Context of Google Maps.* Knowledge building discourse can be defined by progressing mutual understanding rather than simply producing descriptive information for others to agree or disagree with [2]. In this study, a student notes around a place that used to be a coolie house as well as an opium den show how a group of students built on their knowledge about these places by incorporating and clarifying multiple ideas. Prior to the Chinatown learning trail, some of the students created notes on Google Maps on this location by posing questions that interest them, and information they might have found out from their own research.

Additionally, it appears that the students socially constructed meaning from places in Chinatown characterised by discourse when another asked a question, made suggestions, or gave some comments. In the example below, students tried to answer another student’s question and seek to clarify ideas (student names are in bold):

**Henry:** Coolie house and Opium den  
**IMPRESSION:** I thought a coolie house was for coolies to live in. I also thought opium dens were for coolies to smoke opium.  
**RESEARCH:** A coolie house is for Chinese workers to live in. An opium den was for those Chinese workers to smoke opium.  
**William:** When were the coolie houses built?  
**Jia Wei:** Who built this opium dens and coolie houses?  
**Ming:** Some coolie houses are actually Opium Dens. Did you know that?  
Initially, I thought that coolie houses and opium dens were 2 different things, but now I know that some opium dens were actually coolie houses. I am afraid these houses will be demolished because they are old and looks like they may collapse any time.

*Students’ sense of place in knowledge building.* According to Lim and Barton, a place does not simply mean a geographical location, but is defined “as a complicated, ecological system that includes physical, biological, social, cultural, and political factors with history and psychological state of the person who share the location” [15]. In the present study, the Chinatown Heritage Centre (CHC) location marker of some students revealed how the sense of place activated such interdisciplinary thinking about the physical, social, and cultural aspects associated with a particular place. For instance, Yi Hui commented that “CHC does a good job making the place look very real for visitors to feel what it is like in the past so that they can pass down what they have experienced and what they have learned to other people”. She described what life in Chinatown from information she found, and mentioned “Life in the old days were very simple and almost everyone lived in rented cubicles of shop houses” in her impressions. The students’ sense
of place may be attributed to their comparison of living conditions in Chinatown before and today’s environment when they went about their walking trails.

In this note, Yi Hui was able to project the yesterday life of Chinatown she had seen in CHC to the whole area of Chinatown during his walking trail. In the subsequent note, she mentioned “Old shops began to close down, new fashion, electronic shops began to open”, and described the new environment that has been “successfully transformed into a brand new place, not dirty and stinky anymore.” Similarly, Shirley made comparisons between the family life of a coolie and herself in her note about the life of the coolie house and opium den based on these two places:

> From the Internet, I found out that there used to be 12 coolie houses built on one street. A coolie house is a tiny house built for a coolie to stay when they were working as coolies in Singapore. Each house was a house for about twelve coolies. On the other hand, an opium den is a place where you can smoke using opium pipes. Mostly were bought by the rich as it was expensive. They were later banned by the government to open it so it had to be shut down. I feel that we are very lucky now as we can live as a family in a house while coolies have to be separated with their families and squeezed with other coolies in a room. I do not really know how an opium den looked like in the past and I am very keen to find out.

Student perspectives about collaborative knowledge building. Five students were selected to participate in face-to-face interviews regarding their learning experiences. The interviews with students revealed that they were learning from the collaborative knowledge building activities and ideas from their peers. A student remarked, “I feel that I have learned so much from my friends. They have information that I don’t have”. Another commented, “I like asking questions so much after using this Google Maps, I can get quick and accurate replies from my friends, all these make me learn much more than searching for information alone.”

Additionally, using a web-based mapping service like Google Maps provided students with location-based context of building knowledge with textual and graphical representations. In the interview, one student said that “Google Maps is fun and I can add in info or pictures to my Maps whenever I spot any new ones.” Another student mentioned the experience of seeing a same place from different eyes, indicating the shift of students’ sense of place before and after their visit: “After seeing more information posted by my friends, I think there are many things that I have missed out at first and I don’t see Chinatown as only a place for New Year anymore.” A student even made the relationship to the hard work of Singapore’s early settlers when she said “Now then I know Chinatown is so rich in history and all these couldn’t be possible without our forefathers.”

4. Discussion and conclusion

In this study examined the potential of combining mobile computing and the location based application to support collaborative knowledge building in and out of school environments. Like geotagging systems, our design makes it possible for students to create locative content using mobile devices, situated in the real environment of the field trip and enabling them to continue their learning journey and interactions in the virtual space after the field trip. As our results indicated, the students used the Google Maps
space to build on their knowledge about particular locations. It is interesting to see how students’ sense of place activated by the experiences in the Chinatown trail promoted knowledge building discourse and collaborative meaning making. This finding is consistent with the literature of science education that views the potential of places to become “pedagogical centers of experience and meaning making” [16]. This means that a sense of place emerges from one’s lived experiences which is used to build a living ecological relationship between the person and the place [17]. Student notes about the coolie house and opium dens, for example, show that students went beyond factual information about those places, and related their experiences with cultural and social factors.

The number of location markers and the depth of notes were higher than our expectation for this initial study. It seems that students were motivated to answer their guiding questions and to share their knowledge with classmates. Concerning intrinsic motivation for contributing content or ideas in the collaborative environment, Cress and Kimmerle suggest that if we follow Piaget’s model of equilibration, people engage in collaboration knowledge building by contributing new information, or by being driven by cognitive conflict and by incongruities between individual knowledge and the information on the notes. This theory of incongruity may explain student motivation in contributing ideas. In the discourse shown earlier, Ming had realized that his knowledge of coolie houses and opium dens was incongruous with that of other students, and hence he contributed his note. The fact that some students continued to visit the Google Maps site and write notes even after the lesson ended may indicate that they were actively engaged in subsequent knowledge building activities.

From the perspective of cognition, we suggest that the field trip provides a vivid experience to the students as evidenced by the Google Maps notes they contributed during and after the field trips, and by our subsequent interviews. This experience is embodied as they were there visiting and exploring the sites, touching and feeling the place and the artifacts, talking to the folks living there, interviewing some of them, etc. This experience embedded in the real world is translated to a narration of their thoughts, experiences and knowledge, but now situated in the digital realm for sharing and made available for further uptakes and clarifications. The remembrance of the embodied vivid experience might have motivated students to continue their exploration in Google Maps by reading what their classmates might have shared about their own knowledge and experiences.

While it was encouraging to see the possibilities of this new learning space for collaborative knowledge building, we also noticed some challenges that we want to further examine in the future research. Not all students used the affordances of multimedia functions and geospatial representations available in mobile devices and Google Maps. There were few evidences of knowledge building and rise-above at a community level. This may be related to the user-interface issue since it is difficult to track notes (e.g., read/not read notes) and authorships unless and until each location marker is clicked. A further direction is to explore the contributions and artifacts students can create, for example, through augmented the textual thoughts with photos they take or scribble diagrams they make in-situ during the learning trail, and through mash-ups of their artifacts after the learning trail. In conclusion, this study suggests that with the tight coupling of mobile and location-based technologies for pedagogical perspectives, young
learners can be engaged in participatory knowledge building processes linking formal and informal learning experiences. Based on the findings of this initial study focusing on design aspects of mobile technologies, we plan to further examine how to create learning scenarios that incorporate alternative modes of communication and representation, extend collaboration among students across different abilities groups, and support collaborative knowledge building in multiple geographical areas.

Acknowledgements

This study is supported by a grant from the National Research Foundation, Singapore. We are grateful to Wenli Chen, Lung Hsiang Wong, Baohui Zhang, Gean Chia, teachers and students for collaborating with us on this research. Pseudonyms were used for student names for confidentiality.

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