Exploration of Tensions in a Mobile-Technology Supported Fieldtrip: An Activity Theory Perspective

Chih-Hung Lai, Department of Computer Science and Information Engineering, National Dong Hwa University, Taipei, Taiwan
Fei-Ching Chen, Graduate Institute of Learning and Instruction, National Central University, Zhongli, Taiwan
Jie-Chi Yang, Graduate Institute of Network Learning Technology, National Central University, Zhongli, Taiwan

ABSTRACT

The purpose of this study was to analyze how mobile technologies were incorporated and implemented in an outdoor learning activity. Two classes of primary school students participated in the experiment. Using activity theory as an analytical framework, it is found that underlying tensions provided rich insights into system dynamics and that technological affordances could be limited by mismatches between the Tools themselves, and between Tools and the ways that were used by learners or arranged by the instructor. The subtle human factors present in the use of technologies should be carefully considered. The influence of mobile devices on learner experiences in experiential learning is also thoroughly discussed.

Keywords: Activity Theory, Experiential Learning, Field-Trip, Mobile Technology, Tools

INTRODUCTION

As mobile devices are becoming increasingly commonplace on the modern society, researchers argued that mobile technologies have created many new exciting opportunities for learning (Liaw, Hatala, & Huang, 2010; Wu, Hwang, Su, & Huang, 2012). Mobile technologies, such as PDAs (Personal Digital Assistants) and cellular phones, may become an increasingly essential choice of technology for classrooms (Park, 2011) as they can construct an information-rich learning context which integrates learners, peers, the instructor, and the natural environment together with the technology. These learning contexts take advantage of emerging technologies to provide an environment for students that challenges, grounds, and, ultimately, extends their understanding (Barab, Barnett, & Squire, 2002). Mobile technologies afford real-time
information whenever and wherever learners need it as well as a rapid access interface for note taking (Chao & Chen, 2009; Dai, Sears, & Goldman, 2009), such as photo-taking, and sound and video recording, which can aid in retention when out of the learning environment (Lai, Yang, Chen, Ho, & Chan, 2007).

So far, most research in the field of mobile technologies claims benefits to learning based on evidence of learning achievement (e.g., Hwang, Wu, Tseng, & Huang, 2011; Liu, Lin, Tsai, & Paas, 2012; Uluyol & Agca, 2012). However, the barriers of using mobile technologies were understudied. For example, from an activity theory perspective, learning occurs as a socio-cultural system, within which many learners interact to create a collective activity framed by cultural constraints and historical practices (Liaw, Hatala, & Huang, 2010). It is important to determine not only whether mobile technology is usable, but, more importantly, whether it serves to assist learners in achieving desired goals when performing tasks (Norman, 1998). It is therefore necessary to examine further the dynamics that exist among mobile technologies, the context within which they are implemented, and the participants themselves from the socio-cultural perspective.

In the past few decades, there has been much significant development related to field-trip learning. For example, in today’s classrooms there is an increased emphasis on authentic learning in the real world (Linn, 2006). Experiential learning (Kolb, 1984), which has also been widely applied to field-trip learning, emphasizes the process of having students undertake a program of discovery, whereby they develop their own concepts and understanding through experiencing and practicing activities (Abdulwahed & Nagy, 2009; Bergsteiner, Avery, & Neumann, 2010). The aim of the study was to examine the affordances and the constraints of mobile technologies. The authors developed a mobile learning system and a learning flow based on experiential learning to support field-trip activity. To be specific, experiential learning was borrowed as a theoretical framework in this study and mobile technologies were implemented to facilitate field-trip learning.

To analyze the affordance and constraints of mobile technologies from a socio-cultural perspective, the analysis has twofold: Firstly, it compared the knowledge gain of two fifth-grade classes, one of which used mobile devices and the other did not, in order to explain the extent to which mobile technology benefited experiential learning. Secondly, it used activity theory as the methodological framework to analyze the inner contradictions revealed in this activity system. In other words, the study used activity theory as a lens to analyze how each component affects the affordances of mobile technology.

**LITERATURE REVIEW**

Activity is referred to as “a form of doing that is directed towards the fulfillment of an object” (Kuutti, 1996). Activity theory is “a psychological and multidisciplinary theory with a naturalistic emphasis that offers a framework for describing activity and provides a set of perspectives on practice that interlink individual and social levels’ (Liaw et al., 2010). This framework uses ‘activity’ as the basic unit for studying human practices to help researchers understand the relationship between the human mind and activity (Engeström, 1987).

Vygotsky (1978) originally introduced the idea that human beings’ interactions with their environment are not direct, but are instead mediated through the use of Tools and signs. This notion is usually portrayed by what has come to be known as the mediational model of human interactions with the environment (Mwanza, 2002). This model highlights the idea that the relationship between Subject and Object is not direct but is instead mediated through the use of Tools. Engeström (1987) proposed the activity system and expanded the activity triangle model (See Figure 1), to extend Vygotsky’s original conceptualization for the mediated relationship between Subject and Object in order to reflect the collective and collaborative nature of human activity. Engeström’s expanded activity triangle model added social context and cultural aspects.
to the initial theory and stresses the importance of individuals and groups taking action to review, question, and make explicit the origins of values and beliefs (Engeström, 1987).

The activity triangle model incorporates Subjects, Object, and Community components together with the mediators of human activity, namely: Tools, Rules and the Division of Labor. Participants in an activity are portrayed as Subjects interacting with Objects to achieve desired Outcomes (Mwanza & Engeström, 2005). The components of activity systems are not static, existing in isolation from each other, but are dynamic and continuously interacting with the other components, through which process they define the activity system as a whole (Barab, Barnett, Yamagata-Lynch, Squire, & Keating, 2002). The components of the activity system are described as follows (Engeström, 1987).

The ‘Subject’ component of the model portrays both the individual and social nature of human activity through the manipulation of Tools, in order to satisfy desired objectives. The Subjects’ relationship with the Object or objective of the activity is mediated through the use of Tools. The ‘Tools’ component of the model reflects the media aspects of human activity, using both physical and conceptual Tools. Tools could be something as straightforward as a hammer or a wrench, or it may be something much more abstract, such as language. The ‘Object’ component portrays the purposeful or objective nature of human activity that allows individuals to control their own motives and behavior through the manipulation of Tools. The objective of an activity therefore forms the basis for distinguishing the various sub-activities that may exist within the main activity system. The ‘Community’ component of the model puts the analysis of the activity being investigated into the social and cultural context of the organization or environment in which the subject operates. Besides the tool component discussed earlier, the media aspects of the model also incorporate the ‘Rules’ and ‘Division of Labor’ components. The Rules component highlights the fact that within a community of actors, there are bound to be rules and regulations that affect, in one way or another, the means by which activity is carried out. The Division of Labor component refers to the allocation of responsibilities and variations in the job roles of subjects as they carry out activity within the Community.

The activity system was devised to examine how learning would be mediated in a learning
context (Mwanza, 2000) through the internal contradictions (Engeström, 1987, 1993) within and between the sub-triangle activity systems (Kuutti, 1999). Contradictions help to identify problematic areas and to aid in understanding what is happening in the activity system (Kuutti, 1996). Contradictions consist of those within the internal learning systems (sub-triangles) and those that exist between the internal learning systems and other forces (Mwanza, 2000). These contradictions can be regarded as system dualities. Researchers can examine the system design through understanding the interplay within and among these dualities (Barab et al., 2002). In this study, our concern is not simply the interaction between human and mobile technologies, which is of course fundamental, but also the crucial participant-object interactions as mediated by the mobile devices.

A second part of the analysis was conducted by borrowing a framework developed by Engeström (1987) and the procedural model of that framework suggested by Mwanza (2001). The activity system was used as a heuristic model to capture concepts in the analysis of work practices and tool design (Mwanza, 2001). So far, some mechanisms have been proposed to implement the activity theory (e.g., Espinosa, 2012; Law & Sun, 2012; Liaw et al., 2010; Zurita & Nussbaum, 2007). Few of them, however, applied activity theory on analyzing barriers of mobile technologies. This study applied the procedures proposed by Mwanza (2001) to examine the dynamics of mobile technology supported field-trip learning. We briefly cite the standard procedures as follows.

**Stage 1: Model the Situation Being Examined**

We used an Eight-Step-Model (Mwanza, 2001) incorporating open-ended questions to identify the various components of the activity triangle representation. The components consist of activity of interest, Object or objective of activity, Subjects in this activity, Tools mediating the activity, Rules mediating the activity, Division of Labor mediating the activity, Community in which activity is conducted, and what is the desired Outcome from carrying out this activity.

**Stage 2: Produce an Activity System of the Situation**

Using the Eight-Step-Model, while answering questions related to the situation, maps Engeström’s model (1987) onto the situation in order to produce an activity system thereof.

**Stage 3: Decompose the Situation’s Activity System**

This stage breaks down the situation’s activity triangle system into smaller manageable units, sub-activity systems, or sub-activity triangles.

**Stage 4: Generate Research Questions**

Questions that are specific to a particular combination within the activity notation and also represent a sub-activity triangle are then generated. General questions could be generated based on the described approach.

- What Tools do the Subjects use to achieve their objective and how are they used?
- What Rules affect the way the Subjects achieve the objective and how do they affect them?
- How does the Division of Labor influence the way the Subjects satisfy their objective?
- How do the Tools in use affect the way the Community achieves the objective?
- What Rules affect the way the Community satisfies their objective and how do they affect it?
- How does the Division of Labor affect the way the Community achieves the objective?

**Stage 5: Conduct a Detailed Investigation**

A detailed investigation of the situation being examined is then conducted using the questions generated in stage 4. These questions...
are used as pointers to what to look for during observational studies.

**Stage 6: Interpret Findings**

In order to make sense of what is happening within the activity system, data gathered can be analyzed and interpreted in terms of AT’s notion of contradictions. The questions generated in stage 4 can also help to identify areas of contradiction within the activity system.

Based on these stages, this study can be analyzed first by exploring how other components interweave with mobile technology to affect the activity.

Two key relationships were then identified as crucial to the understanding of the means by which activity occurs in the case study class as follows:

- The relationship between the Subject and the Object of activity.
- The relationship between the Tools and the Object of activity.

These two relationships were then examined in terms of other current mediators, namely: Tools, Rules, and Division of Labor.

**RESEARCH QUESTIONS AND THEORETICAL FRAMEWORK**

Based on the stated aims of this study, two research questions were asked to meet the goals and determine the direction of this research:

1. Can mobile technologies enhance learning gain in a field-trip activity?
2. What are the constraints of mobile technologies in a field-trip activity?

The first research question was analyzed by comparing two classes of subjects with one class being supported by PDA devices and the other without. The second one was answered by borrowing activity theory to deepen our further understanding of the dynamics among mobile technology, learners, and the context. Just as in the studies that followed activity theory as an analytical framework, this process also resulted in the production of a ‘broken-down’ triangular representation of the class’s activity, showing sub-triangles that make up the class’s main activity system -- as shown in Figure 2.

**The Activity**

The main activity in this study was identified as exploring knowledge about the African Touch-me-not, whose scientific name is Impatiens walleriana, at a school garden.

**The Object or Objective**

The objective of this activity was identified as enhancing field-trip learning with the support of mobile technology.

**The Subjects**

The subjects involved in this activity were one nature-science teacher and 34 students, 16 boys and 18 girls. The activity can be classified in terms of each student working on his or her own, or as a class of students working in parallel to engage in authentic learning in a novel way.

**The Community**

The community in the study is a grade five class at a suburban elementary school in Keelung city, Taiwan. The location of the learning activity was a small school garden next to a classroom building.

**Mediators (Tools, Rules, Division of Labor)**

The class had several mediators to support the learning activity and satisfy the objective of enhancing experiential learning. These mediators included the use of a PDA (Tools). The teacher and every student had his or her own PDA equipped with sound recording capability and photo-taking capability with a plug-in digital camera. This functionality with its rapid access enabled students to capture more information.
more rapidly. Besides photo-taking and sound recording, the PDA incorporated a mobile learning system (Tools), a learning progress comparison system (Tools), a monitoring system (Tools) and online learning material (Tools). A mobile learning system was to provide prompts and to guide students in following a pre-designed learning flow (Rules). The learning progress comparison system provided a list of the learning progress of all classmates thereby enabling students to compare their own learning progress with that of others. This system was designed to stimulate students’ motivation and focus, since individual learning (Division of Labor) was the main activity. With the monitoring system, the teacher was able to monitor students’ learning status and note-taking and then to give certain students timely assistance if necessary.

To observe more carefully and reflect on what they were learning, students were required to take notes (Rules) during the learning activity. There were three ways to take notes, photo taking, audio recording, and text recording. The PDAs provided speed and convenience, as students used the photo-taking to capture the characteristics and nuances of the observation target, audio recording capabilities to store vocally proposed questions and text format to document their observation outcomes on their PDAs. However, to prevent students from spending too much time on taking photos, the digital camera was collected when the photographing stage concluded (Rules).

In this activity, the learning flow was designed basically in an individual learning fashion (Division of Labor) while the teacher was to monitor students’ learning status and note-taking (Division of Labor) via a monitoring system as well as through direct observation.

The activity triangle model can be divided into six sub-triangles or sub-activity systems. To obtain meaningful data, the research question 2 could be interpreted in relation to field-trip learning as follows.

- How does the use of digital cameras enhance field-trip learning by helping students to observe in detail and to produce a quality final report?
• How does the note taking with sound recording function enhance field-trip learning by helping students to reflect on their observation?
• How does individual student learning affect the way students as a group learns so as to enhance field-trip learning?
• How does the learning progress comparison system affect the way the class learns and how does this contribute to field-trip learning?
• How does the rule of limited time of digital camera usage (imposed in order to prevent students from neglecting the use of their own sense organs) affect the way the class collects information about the plants, and how does this enhance field-trip learning?
• How does the physical environment affect the way the class conducts its field-trip activity?

Learning Environment

The field-trip learning activity is about African Touch-me-not. Students observed the plant in their elementary school campus. The location of the learning activity was a small school garden next to a classroom building. There were a total of about 20 African Touch-me-nots in three nearby areas in the school garden. Students followed a learning flow to explore the African Touch-me-not under the guidance of prompts on their PDAs for with-PDA students (See Figure 3) and on paper for without-PDA students. Students can also take photos with the plug-in camera of PDAs (See Figure 4).

Learning Procedure

In this study, a mobile technology embedded learning flow was developed to support field-trip learning based on the aforementioned experiential learning procedures in the following six stages:

1. Photo Taking: Every student was provided with plug-in cameras of PDA to take photographs to concretely and efficiently capture the features of plants for reference of their final reports. The cameras could record the visual information quickly and gather that information to capture authentic and complex phenomena. These photographs may aid students in recalling information acquired in the learning environment.

2. Sensory Experience: Students obtained sensory experience as prompts on mobile devices led them to “feel” the plants on this stage using various senses – such as taste, hearing, touch, smell, and sight. After this concrete experience, students were required to record their impressions on their mobile devices.

3. Further Observation: In this state, prompts from the mobile devices directed students to observe more deeply than in the previous stage, and again instructed students to record these observations. If students needed background information,
they could access online learning material through their PDAs.

4. **Comparison:** In the comparison stage, the learning system provided the “trap-setting” prompts, which mix correct and incorrect descriptions of observation targets. Students accessed descriptive information about the plants and were thus able to determine whether these statements were correct. The statements were designed to stimulate cognitive conflicts between the materials provided and the direct observations.

5. **Question Proposing:** Through generating cognitive conflicts, this stage guided students in developing questions based on these conflicts as well as their observations. Students could then, conveniently and quickly record their questions orally using the sound recording function of their mobile devices.

6. **Final Report:** After field observations, the students returned to their classroom and wrote paragraphs—their final reports—documenting what they learned about the observation target. These paragraphs were to be placed on plant information plaques composed individually, one by each student. During this process students were able to refer to their photographs, recorded vocal questions, and observation notes. The goals of this stage were to help students organize the knowledge formed in the whole field-trip learning activity and encourage them to conceptualize. Moreover, the final reports reflected students’ abilities to manage previous cognitive conflicts, assimilation, and accommodation.

Before the field-trip learning activity about African Touch-me-not, students were given a pre-test. During the 90-minute learning activity, the teacher first briefly introduced the learning activity.
environment, learning content and the learning flow to the students. It took roughly five minutes. Students then followed a learning flow to explore the African Touch-me-not under the guidance of prompts on their PDAs for with-PDA students, and on paper for without-PDA students. In stage one, namely photo taking, the with-PDA students used the digital cameras to take photos, whereas the other students drew pictures with paper and pencil.

During stage 2, 3 and 4, the two classes of students took notes on PDAs and paper respectively. During the question proposing, stage 5, the with-PDA students proposed vocal questions using their PDAs while the without-PDA students wrote their questions down on paper. During the last stage, the final report, with-PDA students created information plaques by referring to the photographs, vocalized questions and the observation notes they had recorded on their PDAs, whereas the without-PDA students referred to the sketches, written questions, and observation notes they had recorded on paper. After the learning activity, students took a post-test in the classroom.

RESULTS AND DISCUSSION

This study examined the effects of mobile technology support on knowledge gain by comparing two different classes. A t-test was conducted on pre- and post-tests in order to examine the differences between the learning gains in the two classes. Given a situation in which no significant difference existed between two groups’ pre-test scores \( t = -0.37, p > .05 \), the post-test scores of the with-PDA group were significantly higher than those of the without-PDA group \( t = 1.86, p < .05 \). It indicates that the with-PDA group retained more knowledge than the without-PDA group.

Figure 4. A photo taken by the plug-in camera of PDA
It is obvious that merely comparing learning gain does not reveal very much about exactly how mobile technology worked to support or interfere with experiential learning. To understand further the affordances and constraints of mobile technology support for field-trip activity, we then applied activity theory to analyze the field-trip activity of the class with PDAs support.

When analyzing the field-trip learning activity, we not only examined how learning was mediated with the support of mobile technology, but also investigated how the learning was hindered through the use of mediators and other forces in the class context.

The questions generated were also used to help identify areas of contradiction within the class’s activity system. Figure 5 shows the mapping between the sub-activity triangles, the generated questions and the potential areas of contradiction. The generated questions with arrows point to areas where potential contradictions may exist.

Examples of contradictions within and between the internal learning systems (sub-triangles) and other forces in this learning activity are described in turn as follows.

Internal contradictions were identified within the ‘Rules’ component as a result of the introduction of the rule ‘Note taking for reflection’ and rule ‘Limited time of digital camera usage’. During the learning process, with the handy support of the mobile technologies, students were expected to take photos of some important details and simultaneously to take critical notes on what they discovered in the field. On the other hand, as much research has revealed, students tend to wallow in the use of a new piece of technology and attempts
have been made to remedy this by limiting the usage of PDAs so that students will concentrate more on exploring plants with their own sensory organs. However, this situation created internal contradictions within the internal activity, namely limiting the side effects of engaging in novel technology while at the same time attempting to support reflective thinking and experiential learning with that same technology. Using activity theory as an analytical lens, the result shows that the internal contradiction in this sub-activity affected the whole activity of experiential learning because it was difficult to find a suitable compromise on the arrangement of activity flow taking into consideration encouragement of the use of sensory organ, on the one hand and providing technological assistance on the other.

Internal contradictions were also identified between the ‘Community’ and ‘Tools’ components as a result of the operation of the learning progress comparison system. These disturbed the reflective atmosphere. The learning progress comparison system allowed students to be aware of the progress of other students as well as their own. Individual learning has been valued as self-paced learning and has traditionally not disrupted the efficiency of other students. Our observations showed that this system, originally designed for information sharing and teacher monitoring, actually created a competitive culture. This triggered students to care more about the progress of others through the project stages than about their own. Taking reflective notes, for example, was considered by students as ‘side-tracks’ that became regarded as irrelevant to knowledge building because note taking was not reflected in the learning progress comparison system. The competitive atmosphere also seemed to discourage some students from spending time and energy on note-taking in any format. Therefore, the tool “learning progress comparison system” appeared to be in direct contradiction in the sub-activity systems “Community-Rules-Object” and “Community-Tools-Object.”

CONCLUSION

Research has shown the importance of a theoretical framework for evaluating technology-enhanced learning. Until now there has been little research on how to understand the dynamics of technology and learners systematically while taking into account social and contextual aspects (Bielaczyc, 2006). Previous research has generally concerned itself with how mobile technology can be used to benefit learning. Besides exploring learning gain, this study, however, focused upon identifying and finding tensions embedded in a mobile technology supported fieldtrip activity using activity theory as an analytical framework.

From a two-level approach, this study explored how exactly mobile technology such as the PDA supported or hindered students in a learning activity. The first level was to use an experimental design method combined with pre-test and post-test to justify the hypothesis that, with PDAs, the class gained more knowledge than that of the without PDAs class. The second level was to apply the extended form of the activity theory framework coined by Engeström (1987) to analyze classroom settings (including the outdoor setting) in order to identify any problem with the newly implemented technology. Several problems and tensions were identified. For example, the internal contradictions within “Rules”, “limited time of digital camera usage” and “note-taking for reflection”, make it difficult to find a suitable compromise in the sub-activity system between snapshotting interesting pictures and taking time to reflect on what to put into the plaque at later stages. This deserves further investigation. The internal contradictions between components, the “physical environment” and the “sound recording function”, also render it difficult for the sub-activity system to reach the designed goal of reflective thinking right in the field.

These two levels of analysis provide both macro- and micro-level accounts. The experimental design methods provide a product-oriented picture of the effects of mobile technology upon learning; however, it is the activity theory
framework that reveals the inter-relationships between components (e.g., the multiple Tools and the emerging Rules) as well as among sub-activities. For example, the Tools “learning progress comparison system” originally introduced simply for reference changed the learning atmosphere totally since subjects were not actually working independently and became preoccupied with what others did to the exclusion of furthering their own concentrated observation. These Tools were not explicitly assigned for use at any particular stage. Therefore, without considering the activity as a unit of analysis, we would not be able to identify this item as a critical component and to explore how it interwove with others to influence learning. Only by understanding the critical variables involved, it is possible to develop a deep understanding of how and why a technology-enhanced classroom works or does not work.

This study, in a sense, can also be a demonstration of one-to-one technology-enhanced learning (Chan et al., 2006) with seamless learning space. Students bring their individual mobile devices out for plant observation and then they go back to the classroom where, they retrieve the photos and vocal questions proposed earlier, and follow the learning flow in a PDA to compose their unique information plaque for the plants observed. The seamless switch between different contexts demonstrates numerous learning scenarios which signal a salient feature of seamless learning space. However, in the implementation of this study we are alerted to the fact that, in a G1:1 world, not all properties of one-to-one devices make a contribution, depending upon arrangement and deployment. For example, the feature of portability may not compensate for problems of improper arrangement of physical environment; by the same token, connectivity among distributed devices may not always contribute to all kinds of learning activities. It is obvious that G1:1 activities need careful investigation (such as using an AT framework) before one can claim that they are affecting fundamental shifts in the way people learn under any specific circumstances.

Finally our research results raise an interesting question about how well the mobile technology improves experiential learning. From the perspective of a theoretical underpinning, observation and reflection are the core activities no matter whose model is applied (i.e., Lewin, Dewey, or Piaget, in Kolb, 1984), while from a practical standpoint, the use of mobile technology might present a risk of superseding the sensory experience, which is one of the most valuable aspects of experiential learning. There are alternative explanations. It seems that most of the disadvantages of these PDAs in the learning environment stem from their novelty and unfamiliarity. It’s important then to ask whether these problems are just transient blips that exist only during the incipient stages of this technology. However, how students can best be supported in quality experiential learning environment certainly deserves further attention.

ACKNOWLEDGMENT

This study was based upon work supported by the National Science Council of Taiwan under Project NSC 102-2511-S-259-009-MY3.

REFERENCES


Norman, D. A. (1998). *The invisible computer: Why good products can fail, the personal computer is so complex, and information appliances are the solution*. MIT Press.


Chih-Hung Lai is a professor in the Department of Computer Science and Information Engineering of National Dong Hwa University, Taiwan. He received his PhD degree in Department of Computer Science and Information Engineering from National Central University. He has won Distinguished Person Award on Computer Education from Ministry of Education. Dr. Lai’s current research foci on learning technology, computer assisted language learning, and mobile learning.

Fei-Ching Chen is Professor of Learning Sciences in the Graduate Institute of Learning & Instruction at National Central University, Taiwan. She teaches activity theory and communities of practice, with a focus on applying these theories to problems of online group learning. Her current research centres on knowledge building, teacher collaboration, and collective ownership of elementary students in collaborative problem posing.

Jie Chi Yang is currently the Head of the Graduate Institute of Network Learning Technology and a Distinguished Professor at National Central University, Taiwan. He received his PhD from the Department of Human System Science at Tokyo Institute of Technology, Japan, in 2000. His research interests include digital game-based learning, computer assisted language learning, mobile learning, and multimedia technologies.