The Development and Evaluation of a Mobile Simulation Tool for Reflective Learning

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ABSTRACT

This paper presents the development, implementation, and evaluation of a mobile simulation tool to facilitate students' reflective thinking. Through the pedagogical underpinning of "reflection-in-action" and short messages services (SMS) of cellular phones, the study explored the use of a mobile device as a learning tool to enhance novice learners' knowledge construct and sharing on the problem-solving of the Linux Fedora installation. The learning difficulties of novices and the challenges involved in the development of the system will be duly described. Based on self-reports and questionnaires, the students' feedbacks are investigated and examined. The results revealed that learners show positive attitudes toward using the mobile learning device to enhance IT learning. Finally, for these implementations to be successful in further studies, several emerging patterns are discussed.

1: INTRODUCTIONS

Learning and teaching with mobile technologies is beginning to make a breakthrough from small-scale pilots to institution-wide implementations. Researchers have repeatedly demonstrated these technology abilities to scaffold students' learning of well-structured tasks such as natural exploration [1], environmental and geographic observation [2], or scientific experiments [3]. Based on information accessibility, mobility, and adaptability, mobile devices have become a promising technology for learning [4].

However, studies [5] have recently begun to identify several problems associated with learners' inability to elaborate their learning in learning environments with novel technologies. In a study on collaborative contextual applications of mobile devices [6], researchers contended that the use of technology for learning must go beyond the simply technology determinist viewpoint which claims that it is inevitable that mobile technology will have a role to play in the way we learn. They also suggested that the development and use of mobile devices should suit the pedagogical underpinning in order to facilitate learning in a pedagogically sensible manner.

This paper describes the use of mobile device (video phone with 64MB MMC memory) and the development of a prototype of Linux simulation tool to facilitate reflective thinking through the pedagogical underpinning of "reflection-in-action" during instructional simulations. It is worthwhile to evaluate and understand how mobile environments with better scaffolding and interaction design can impact on students and participants. Based on self-report and questionnaire, the learners' attitudes toward the mobile applications are investigated and several emerging patterns are discussed.

2: RELATED WORKS

The recent development of handheld devices tends to merge the portability and connectivity features together. Ubiquitous mobile technologies provide much scope for designing innovative learning experiences that can take place in a variety of settings [7]. Rochelle and Pea suggested that the new mobile technologies might facilitate the emergence of new forms of supportive learning that could better suit the individual's learning needs [8].

In addition to portability and affordability, Pownell and Bailey [9] claimed that there are other advantages set handheld devices apart from the desktop computer, such as accessibility, mobility, and adaptability. Thus, the designing and developing approach of mobile learning activities were developed to various categories.

2.1: Different categories of mobile learning

According to the activity-centered perspective [10], mobile learning activities could be classified into six broad theory-based groups:

1. Behaviorist - activities that promote learning as a change in learners' observable actions;

2. Constructivist - activities in which learners actively construct new ideas or concepts based on both their previous and current knowledge;
3. Situated - activities that promote learning within an authentic context and culture;
4. Collaborative - activities that promote learning through social interaction;
5. Informal and lifelong - activities that support learning outside a dedicated learning environment and formal curriculum;
6. Learning and teaching support - activities that assist in the coordination of learners and resources for learning activities.

Because of the inclination toward the focus on theory inquiry, most studies in pedagogical fields favored the constructivist, situated and collaborative learning categories [3], [6], [11]. However, researchers in computer science and mobile technology put more emphasis on the development of mobile application tools or the complete learning systems [12]-[14]. Therefore, mobile learning environment projects always make use of the technological connectivity and affordability to facilitate the sharing of data and communication among their classmates in collaborative manner.

In this paper, the simulation tool aims to act as an optional short pre-experiment and revision exercise. Therefore, most of the work were expected to be performed individually and interaction asynchronously. The constructivist and collaborative learning approach is the most suitable implementation approach for the system and has been duly adopted.

2.2: Simulation making conceptions clarifying

Simulation and visualization are valuable tools on handheld devices for developing students' understanding of concepts taught in classrooms by providing hands-on experiences [16]. The procedural simulation not only employs animations to demonstrate the installation procedure to the learner visually but also allows learners to interactively control, manipulate, and navigate in the simulated processes. Therefore, the learner's cognitive load can be reduced and the learning performance can be facilitated [17].

2.3: Reflective dialogue supported by SMS

There is growing intention that education should be involved in transforming students into critical reflective thinkers able to cope with a rapidly changing world.

Mobile technologies enable children to interact simultaneously with both the physical world and digital information. However, it is argued that reflection can be promoted by coupling familiar actions within the physical environment with the unfamiliar digital resources. Thus, new applications aiding children's learning in the mobile environment should be achieved.

In [15], through using the short messages services (SMS) on cellular phones, a reflective dialogue system was implemented. Researchers successfully integrated the digital contents into classroom learning offers a promising way for enhancing the reflective process.

3: TASKS AND CHALLENGES

Teaching computer science to college students is experiencing a paradigm shift from simply delivering established facts and procedures to engaging students in active learning that resembles more the "inquiry oriented" practice of computer engineers. Hands-on activities are recognized as an important way to foster inquiry-based learning for novice learners. In the computer science context, simulation and visualization tools become an essential part of many computer science curricula.

Our project, the Linux Fedora system was introduced in Operation System course for learners to become familiar with the basic concepts and skills during the hands-on laboratory. The procedural simulations of the Fedora system installation were developed and delivered through the mobile learning device to scaffold learners' successful learning experiences. The structure of the hands-on laboratory sessions included four units: basic UNIX navigation, building a Linux system, setting and managing the services, and useful applications. This study presents the trial results of using mobile devices and instructional procedural simulations to enhance the building of a Linux system in the second laboratory session, which lasted 2 weeks, totally 6 hours, in completing the Fedora system installation.

In this study, a mobile simulation tool was developed to provide scaffoldings for facilitating learners' reflective thinking among other students. Based on the teaching experiences in previous semesters, the learning difficulties encountered by novice learners' can be categorized into the following aspects:

1. With comparison to the more intuitive Microsoft OS, learners show great fear toward Linux.
2. Building a Linux system takes many tedious steps that can be accomplished successfully only when the learner catches all the essential knowledge.
3. Any faulty action during the process could undermine the whole building process and the learner has to re-do the process from the beginning.
4. Partitioning the hard disk is a serious destructive action so that learners' cautiousness sometimes undermined the learning progress.
5. The highly flexible characteristic of the Linux system offers so many alternatives that always confuse the novice learner.
6. It is difficult for the teacher to diagnose an individual's misconception during the hands-on session.

Therefore, the motive of this work is to make the learning task more effective and beneficial for novice learners and to provide an interesting and successful learning experience for learning the Linux system.

4: SYSTEM ARCHITECTURE

The mobile learning environment of this paper consists of instructional simulations, reflection-in-action prompts, and SMS mechanism. The pedagogical design of system architecture in this paper is shown in Figure 1.

Figure 1: The pedagogical design concepts: individual elaboration, reflective thinking, and collaborative

In the mobile environment, the learners access to the simulation tool everywhere for individual elaboration. Then, the system pop-ups a reflective prompts window for reflection-in-action on learning. Students deliberate on the simulation and write down the think-aloud result via the scaffolding questions. Eventually, the reflection messages will be uploaded to the gateway server for sharing and collaborative learning by SMS mechanism. The function diagram of the system architecture is shown in Figure 2.

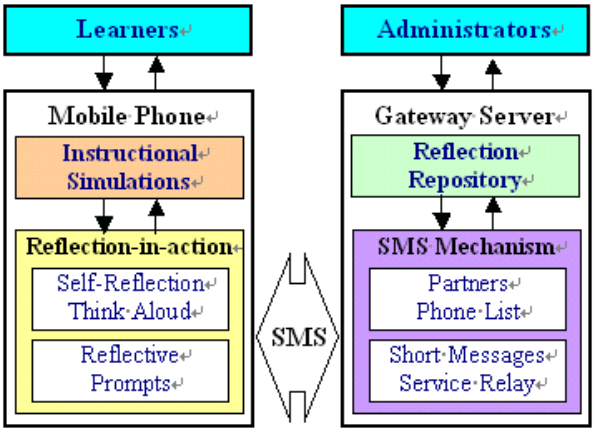

Figure 2: The system architecture of the simulation tool for enhancing reflective thinking

4.1: Instructional simulations

There are five procedural steps of the unit 4 lab "Building a Linux system" provided through the mobile system, consisting of preparation, partition disk, network setting, packages selecting, and post-installation. Learners can access to the simulations and the embedded reflection scaffoldings using the mobile device anytime, anywhere. The instructional simulation shown on the mobile device screen is illustrated in figure 3. Learners can virtually practice the Fedora system installation through the interactive simulations.

4.2: Reflection in action

"Reflection in action" is the thinking during a problem-solving process without interrupting it [18]. Many studies [19]-[20] suggested that the cognitive process of generating "reflection-in-action" in the problem-solving tasks could improve learning.

In this study, the "reflection-in-action", reflective thinking on a faulty action during the problem-solving task, was enhanced when learners respond to the system prompts and summarize what they had learned while encountering an erroneous action during the instructional simulations. The "reflection-in-action" task is illustrated in the mobile device screen in Figure 4.

Figure 4: The scaffolding screen of reflective prompts and self-reflection think-aloud

(a) (b) (c) (d) (e) (f)

Figure 3: The instructional simulation screens of (a) start-up menu (b) Preparation unit (c) Disk Partition unit (d) Network setting unit (e) Packages selection unit (f) Post-Installation unit

4.3: Reflection sharing with SMS

Studies among student populations report on 80% of students sending short messages service every day [15]. Recently, the development of handheld value-added services, the SMS has become the most popular application on cellular phones. Researchers have indicated that SMS is an area for further exploration in education, such as social discourse, in-class discussions, or vocabulary learning.

Through the software design, the reflective thinking of learning processes would be sent to the SMS gateway server by function call of the embedded codes of mobile phone. Then, the messages from all participants will be collected into the reflection repository for further inquiry and relay to other learning partners for reflection sharing by the SMS mechanism.

5: EVALUATION & FEEDBACKS

A formative evaluation on the mobile learning system was carried out through interviews with four instructors and eight students who were teaching or taking the operation system courses. All the participants were asked to complete the instructional simulations on the mobile learning system, and then semi-structured interviews with eight open-ended questions were conducted. The guiding questions are shown in Table I.

Table I: The guiding questions of evaluation

No.	Guiding Questions
1	Have you ever used any mobile application for education?
2	How useful is such Mobile Education System on Linux Installation to you?
3	Do you think that using the Mobile System can provide you with the quality and quantity of reflective thinking?
4	Does the Mobile Education System prototype presented to you here show enough evidence that it can be a good complement to the existing learning tools?
5	Does the prototype show enough evidence that it will bring more convenience to the learners?
6	Do you think that the user interface of the prototype is easy to use?
7	What was the most beneficial feature in the Mobile System?
8	Will you suggest your teachers use this prototype of Mobile Education System in other subjects?

The feedbacks from the participants revealed that most of the participants have experience in using web-based learning materials regularly. Participants showed preferences toward integrating the simulations and mobile devices for the following reasons:

- It provides easy access to the instructional information such as lecture notes, advanced reading, and assignments.
- Mobile technology is getting popular.
- It provides convenient and easy ways for use.
- It is wireless and can be used in various places such as on a bus or MRT train.
- It is convenient for students to learn while out of campus.
- It can be a good reflection tool.

Participants also expressed their concerns toward using the mobile technology:

- The cost of mobile device and wireless connection
- A desktop system is enough.
- The data transmission speed is slow and the quality of connection is affected by buildings.
- The sizes of screen and keyboard on mobile devices are not easy for use.

6: Conclusion

In this preliminary study, the development and use of mobile learning devices was based on the pedagogical needs in order to facilitate learning in a pedagogically sensible manner. Although the employed mobile device was limited in the size of display and ways of input, learners showed highly preferences toward its features in facilitating reflective thinking and mental model construction of the Linux Fedora problem-solving task. Our reflections on the responses from the participants during and after the trial of the mobile learning system can be summarized as the following.

6.1: Learning with fascinating technology

Mobile devices as a leading-edge technology, such as PDA, smart phone, or Tablet PC, are exciting to students with some technology novelty. Students are likely to be motivated and become more engaged in learning activities when the new technology is used in a meaningful way.

6.2: Making application more authentic

Authentic learning, by constructivists' perspective, is situations that allow learners to construct their own personal knowledge in a particular task environment. In a way, the authentic learning can be achieved through virtual actions on actual problem-solving scenarios.

6.3: Minds on knowledge seeking

Furthermore, the mobile device can be an effective tool for student's knowledge sharing and constructing. We discovered that students became more active in information comparing, more curious on experimenting phenomena, and more often in communicating with each other for coordinating classroom work.

6.4: Reflective thinking as effective strategy

The cognitive function of self-reflection includes not only awareness of reasoning and reflecting but also

controlling one's cognitive skill and processes. From this preliminary study, we found that mobile learners need more skillful self-regulation in order to focus on goal-oriented actions during the active learning process. Self-reflection seems to be an important and effective strategy for scaffolding mobile learning.

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