Enhancing Reflective Thinking On IT Problem-Solving Through The Use Of Mobile Learning Devices

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Abstract: This study explored the use of a mobile learning device as a learning tool to enhance novice learners' reflective thinking through "reflection in action" and "reflection on action" on the problem-solving of the Linux Fedora installation. Instructional simulations of the Fedora system were provided through the mobile device to enhance novice learners' learning. The learner's reflective thinking was enhanced by responding to the reflection prompt and summarizing what he/she had learned while encountered a faulty action during the simulations. Learners' "reflection on action" was facilitated through reflecting, sharing, and discussion using the web-based discussion forum. The results revealed that learners showed positive attitudes toward using the mobile learning device to enhance IT learning.

Introduction

In the recent years, handheld devices have become a promising technology for learning. Pownell and Bailey (2000) asserted that this evolution is part of the fourth wave in the development of educational technology with very small computers and wireless connectivity delivering "anyone, any time, anywhere learning". Handheld devices were suggested to increase learners' motivation, promote interactive learning, facilitate cognitive skills development, and support constructivist educational activities through collaborative groups (Dede & Sprague, 1999; Zurita & Nussbaum, 2004). Crawford and Vahey (2002) also concluded that the most often cited benefits of handheld technology include portability, ease of access, the integration of computers into a variety of education activities, promoting autonomous learning and organization, promoting student motivation, promoting communication and collaboration. Studies also showed that students and teachers respond favorably to handheld applications (Rochelle, 2003). Today, the web-based mobile technologies have already had a significant impact on ways to organize learning and studying (Roschelle & Pea, 2002; Soloway, Norris, Blumenfeld, Fishman, Krajcik, & Marx, 2001).

Patten, Sanchez, and Tangney (2006), however, 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 suggested that the development and use of handheld devices should suit to the pedagogical underpinning in order to facilitate learning in a pedagogically sensible manner. Roschelle and Pea (2003) also suggested that wireless internet learning devices should support computational media with cognitively-empowering representations such as simulations, manipulable mathematical notations, modeling tools, diagramming tools…etc, in order to facilitate learning.

This paper describes the use of a wireless personal digital assistant and instructional procedural simulations within a web-based collaborative environment to facilitate reflective think through the pedagogical underpinning of "reflection in action" during instructional simulations and "reflection on action" in the web-based discussion forum.

The Theoretical Framework

Portability and connectivity making learning personalized and interactive

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 (Rogers, Price, Randell, Fraser, Weal, & Flitzpatrick, 2005). Rochelle and Pea (2002) suggested that the new mobile devices may facilitate the emergence of new forms of supportive learning that could better suit to the individual's learning needs. The portability gives the handheld devices the potential for pervasive use in students' note-taking, homework-completing, test-taking, problem-solving, data-collecting, program-writing…etc that may facilitate learning far more widely and deeply than the desktop computers. The handheld mobile devices allow the mobile learner to communicate with experts, peers, or other materials effectively in the form of synchronous or asynchronous communication. Hence, with the help of the mobile devices' connectivity, the expert is more reachable and the knowledge is more available (Chen, Kao, & Sheu, 2003).

Simulation and visualization 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 experience (Margolis, Nussbaum, Rodriguez, & Rosas, 2006). 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 (Schnotz & Rasch, 2005).

Reflective thinking making cognition elaborative

Computer-based tutorials are frequently cited as offering opportunities for reflective thinking through the use of tutorial and feedback. The reflective dialogue can be supported using the computer-mediated communication (Seale & Cann, 2000). Digital augmentation in mobile learning environment offers a promising way for enhancing the learning process (Rogers et al., 2005). Mobile technologies enable children to interact simultaneously with both the physical world and digital information. It is argued that reflection can be promoted by coupling familiar actions within the physical environment with the unfamiliar digital resources, thus new ways of aiding children's learning can be achieved (Facer, Joiner, Stanton, Reid, Hull, & Kirk, 2004).

Learning 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. In this study, the Linux Fedora system was introduced in Computer Networks course for learners to practice the computer networks practitioners' skills during the hands-on laboratory sessions. The procedural simulations of the Fedora system installation were developed and delivered through the mobile learning system to scaffold learners' successful learning experiences. The structure of the hands-on laboratory sessions is shown in Table 1. There are four laboratory sessions, including the basic Unix navigation, building a Linux system, running servers, and security. 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.

Table 1: The topics of the laboratory sessions

1. Basic Unix navigation
- a. How to move about the file system
- b. Opening/closing/moving/copying/deleting files and directories
- c. Users and groups, home directories, passwords, access
- d. Networking, basic configuration and concepts

2. Building a Linux (Fedora Core) system
- a. Choosing a supported distribution
- b. Steps necessary to build a system from empty disk to fully functional on the internet
- c. Workstations vs. Servers

3. Running servers
- a. SSH - Your gateway to do anything remotely
- b. Web server with Apache
- c. Mail with Postfix
- d. DNS with Bind, DNS change root
- e. NFS for file sharing
- f. Gateway with NAT
- g. DHCP for dynamic IP assign

4. Security
- a. Password security
- b. SSL Certificates
- c. Firewall with IP Tables/Shorewall
- d. Intrusion Detection
- e. System remediation after a break-in

In this study, a mobile collaborative learning system was developed to provide scaffoldings for facilitating learners' reflective thinking. 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 and user-friendly Microsoft systems, learners show great fear toward the Linux system.
2. Building a Linux system takes many tedious steps that can be accomplished successfully only when the learner catches the essential knowledge of the system.
3. Any faulty action during the process could undermine the whole building process and the learner has to re-do the process from the very beginning.
4. Partition the hard disk is a serious destructive action to the computer system. 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.

System Architecture and Implementation

The mobile learning system consists of a mobile learning device and a web-based collaborative learning environment. The mobile learning device provides the instructional simulations and the "reflection in action" scaffoldings. Meanwhile, the "reflection on action" mechanis m, student models, and other learning resources were implemented in the web-based collaborative learning environment. The system architecture of the mobile learning system is shown in Figure 1. The learners access to the instructional simulation and reflect in action via the mobile device. A learner's reflections during simulations will be uploaded to the server for later reflection and sharing.

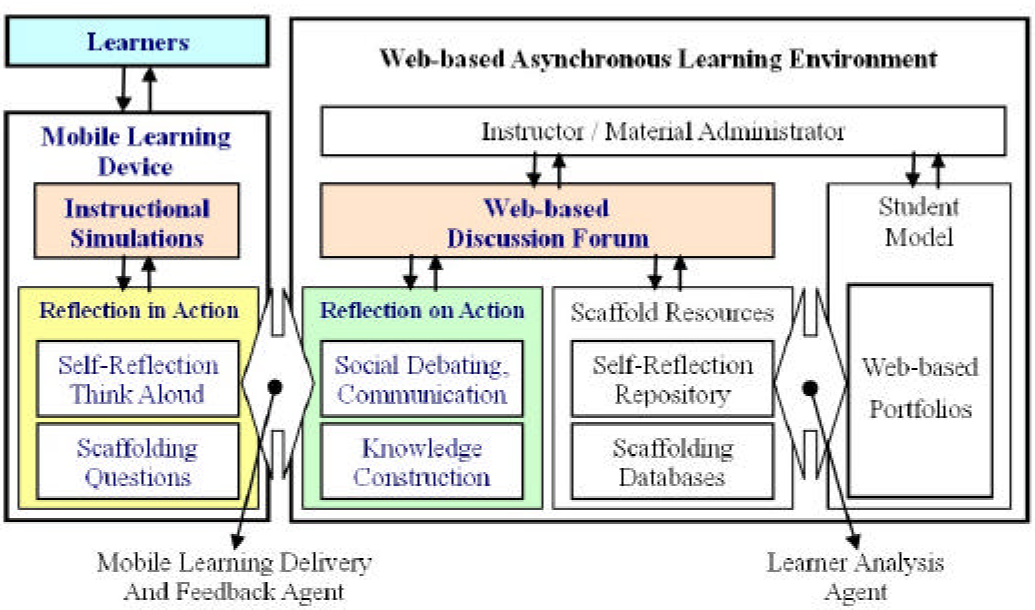

Figure 1: The system architecture of the mobile learning system for enhancing reflective thinking

Instructional simulations on mobile devices

There are twelve procedural simulations of the complete Fedora system provided through the mobile device. Learners can access to the simulations and the embedded reflection scaffoldings using the mobile device. The instructional simulation shown on the mobile device screen is illustrated in figure 2. Learners can virtually practice the Fedora system installation through the interactive simulations.

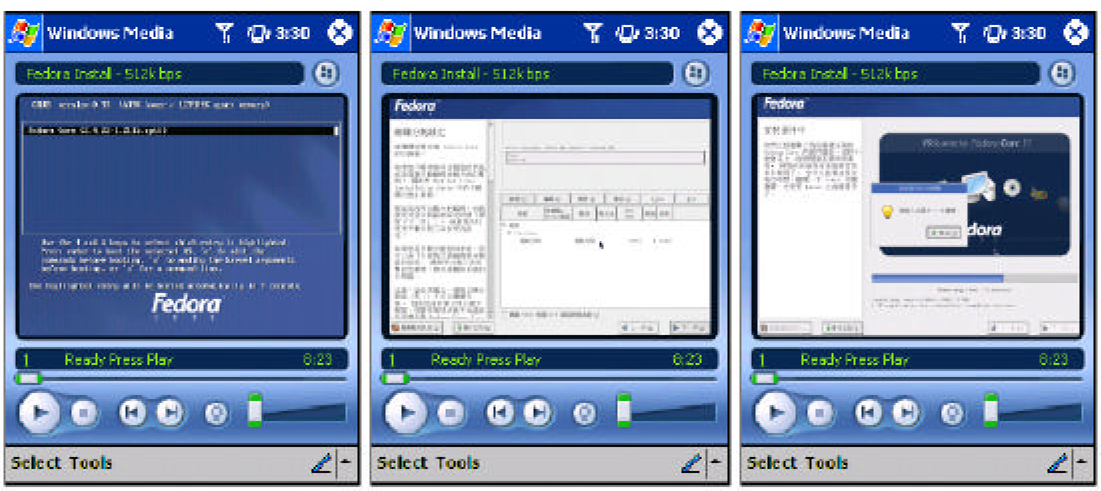

Figure 2: The instructional simulation screens of (a) Start-up (b) Disk partition, and (c) System installation shown on the mobile device

Reflection in action and reflection on action

"Reflection in action" is the thinking during a problem-solving process without interrupting it, and "reflection on action" is the thinking back after an event or experience on what a learner has done in order to find out how the employed knowledge may have contribute to an unexpected result (Seale & Cann, 2000). Many studies (Gay, Rieger

& Bennington, 2002; Horton & Wiegert, 2002) suggested that the cognitive process of generating "reflection in action" in the problem-solving tasks can improve learning. In this study, the "reflection in action", reflective thinking on an faulty action during problem-solving, was enhanced when learners responding to the system prompt and summarizing what they had learned while encountered an error action during the instructional simulations. The "reflection in action" is illustrated in the left mobile device screen in Figure 3. During the web-based discussion forum, "reflection on action" was enhanced while a learner thinking back on what he/she had done to cause the unexpected result and while a learner sharing experience and discussing problems with others.

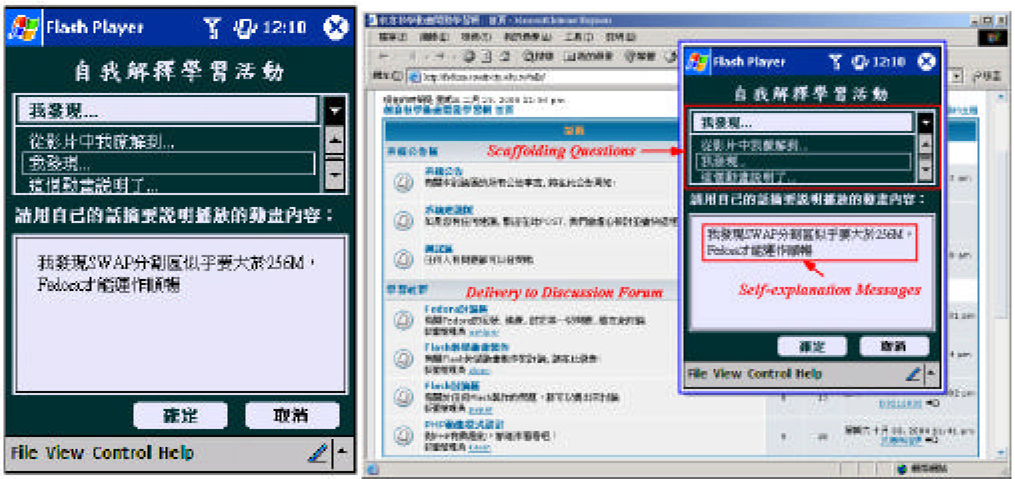

Figure 3: The mobile device screen on the left shows the "reflection in action" during an instructional simulation, and the PC screen on the right shows the "reflection on action" in the web-based discussion forum.

Formative Evaluation on the Mobile Learning System

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 computer networks course. All the participants were asked to complete the instructional simulations on the mobile learning system, and then semi-structured interviews with five open-ended questions were conducted.

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

1. It provides easy assess to the instructional information such as lecture notes, advance reading, and assignment.
2. Mobile technology is getting popular.
3. It provides convenient and easy ways for use.
4. It is wireless and can be used in various places such as on a bus or MRT train.
5. It is convenient for students to learn while out of campus.
6. It can be a good reflection tool.

Participants also expressed their concerns toward using the mobile technology:

1. The cost of mobile device and wireless connection
2. A desktop system is enough.
3. The data transmission speed is slow and the connections are affected by buildings.
4. The size of screen and keyboard of mobile devices are not easy for use.

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. Our reflections on the responses from the participants during and after the trial of the mobile learning system can be summarized as the following.

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, in Taiwan. Students are likely motivated to be more engaged and activated in learning activities when the new technology is used in a meaningful way.

Making application more authentic

Authentic learning, by constructivists' perspective, is situations that allow learners to create 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.

Recently, handheld device has become the most conveniently use and portable learning platform for various educational purposes. The desktop application such as notepad, calculator, vision and audio recording, scheduling management are gradually shift to outdoors for more authentic.

Minds on knowledge seeking

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

Reflective thinking as effective strategy

The cognitive function of self-reflection not only includes 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 skillfully 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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