Integration of Project-Based Learning Strategy with Mobile Learning: Case Study of Mangrove Wetland Ecology Exploration Project

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Abstract

Technologies, such as mobile learning and online inquiry, would be used to create virtual versus real learning effects. In order to enhance the quality of the ecological environment learning projects in school settings, we integrate Project-based learning (PBL) strategy to develop an e-learning platform, and help students exploring their outdoor learning tasks with mobile learning technology. The main idea about the design and development of e-learning platform integrated PBL strategy, how to use mobile learning technology in the PBL learning tasks, and the feedback about PBL exploration from students are discussed in this study.

Key Words: E-Learning Platform Development, Project-Based Learning (PBL), Mobile Learning

1. Introduction

Given the growing popularity of e-learning in many Internet-based technology applications, m-learning is increasingly adopted for learners in or outside of traditional educational institutions. By full exploiting the capabilities and characteristics of mobile technologies, educators and software developers can create learning opportunities in various subject curricula.

Ecological and climatic changes globally, including global warming, climatic instability, frequent earthquakes and even volcano eruptions, have profoundly impacted daily life. Limited integration of instructional materials in the Taiwan educational system with practical life circumstances explains the largely indifferent or unaware general public towards environmental issues. In addition to focusing on the "cognitive" level, environmental education should also incorporate "affective" and "psycho-motor" skill levels. However, the traditional lecture method in education can neither satisfy the above three levels nor accurately reflect the real situation of our living environment. As constructivist pedagogy, project-based learning (PBL) allows students to adopt an inquiry based approach to address issues and raise questions relevant to the topic under study. PBL is also designed for confronting complex issues that require students to investigate for a more thorough understanding [1]. Therefore, this work presents a virtual and realistic learning environment that integrates PBL and mobile technology for students to explore the Mangrove Wetland Ecology environment. With this innovative learning approach, students are instructed to adopt technology meaningfully to present their study findings and, in doing so, their higher-order thinking and problem solving skills are strengthened.

2. Project-Based Learning Strategy

PBL, an instructional strategy, train learners on how

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to fully utilize acquired knowledge, skills and attitudes to solve problems and adapt to unforeseen circumstances in real life [2]. PBL also integrates subject-matter goals with an authentic learning environment [3]. Using authentic activity as a model for appropriate pedagogical activities is thus intended to increase learning effectiveness by applying knowledge within a specific context. Namely, PBL provides productive environments to develop meta-cognition skills [4]. Additionally, among the factors identified to enhance classroom are learning active engagement, group participation, frequent interaction and feedback, and connection to a real-world context. In sum, PBL can enhance problem solving and higher-order thinking skills of students.

2.1 Features of Project-Based Learning

Krajcik et al. [5] identified five features of PBL that teachers are familiar with as driving questions, investigations, artifacts, collaboration and technological tools. Based on an exhaustive literature review, features of PBL projects are as follows:

1. A question and problem directs related activities that result in a summary report or product [6];
2. A product, presentation or a performance can be improved and applied for practical purposes;
3. Real life problems that students are interested in are raised so that they can interact with real life circumstances through the projects [7];
4. Students can develop products or works to solve questions or problems raised during learning [2];
5. Students collaborate in a team to achieve certain objectives in a defined time period [8,9];
6. Many disciplines are incorporated, allowing students to create multidisciplinary approaches to solve problems [7];
7. Students can define the problems, discuss views or forecasts, collect information, evaluate such information, make conclusions, create a product [10], and construct required knowledge [2].

2.2 PBL Process

PBL emphasizes developing products to create a learning situation. In particular, students analyze previous literature, create a plan, perform related research, as well as summarize and share new knowledge. While a final product provides evidence of completed learning activities, PBL focuses mainly on the learning process and practical experiences. Successfully completing a PBL project requires that students perform the following steps [11,12]:

1. Define problems and tasks.
2. Develop a strategy.
3. Collect information from pertinent literature.
4. Investigate a given situation and implement the proposed project.
5. Provide feedback and revise the proposed project.
6. Present the project in written and/or oral form.
7. Reflect upon the project findings and evaluate the work.

3. Mobile Learning

Mobile technology advances have made it increasingly appealing for educators to integrate it into learning, and formulate a mobile learning, or m-learning, curricular approach. Characterized by wireless and handheld devices (commonly referred to as wireless/handheld (W/H) devices) [13], mobile learning represents an important educational trend given its ability to eliminate limitations of space in which learning and teaching can extend beyond the classroom. Additionally, the system (or platform) that communicates with mobile devices is also vital to constructing a mobile learning environment. In sum, mobile technologies provide a reliable educational alternative, with mobile devices offering an individual learning environment in daily life.

3.1 Features of M-Learning

By utilizing wireless networks as a learning environment, m-learning should improve communication and collaborative interaction, provide additional learning opportunities for geographically dispersed individuals and groups, encourage active learning, enhance learner feedback, emphasize assigned tasks, and acquire learning contents efficiently [14]. Furthermore, Sharples et al. [15] characterized m-learning as personalized, learner centered, situated, collaborative, ubiquitous, and lifelong.

3.2 Framework of M-Learning

M-learning consists mainly of handheld devices, wireless communication technology and instructional design activities. Chang et al. [16] suggested the follow-

ing elements to construct a mobile learning framework:

1. Learning activity module: Mobile learning activities can be categorized as individual in-door mobile learning, individual out-door mobile learning, group indoor mobile learning and group out-door mobile learning [17].
2. Infrastructure: Via AP, base station, GPRS network or other technologies, the infrastructure includes a communication environment that provides mobile learning devices to connect learning materials.
3. Mobile learning device: Mobile learning includes the use of small and portable wireless devices such as PDAs, Tablet PCs, notebook computers, and cell phones.

4. Integration of PBL Platform into M-Learning Technology

While attempting to integrate instructional elements of PBL strategy and m-learning features, this work presents a novel PBL-based e-learning platform using mobile technology. Conducted in small groups, PBL fosters discussion and collaboration since participants must devise a solution for a specific problem or a set of problems. A tutorial leader or facilitator who shares information guides the group through the learning process [18]. Based on the above PBL activity requirements, mo-

bile learning technology features are also incorporated, i.e. learning activity module, infrastructure, and mobile learning device. Therefore, a PBL activity is undertaken as a learning activity module, followed by use of an AP, base station, and GPRS network to construct a communication environment. Moreover, a tablet PC and digital camera are selected as the mobile technology devices.

4.1 Module Design of PBL Activity

To fulfill PBL activity and mobile learning requirements, this work analyzed several well-established PBL websites, including the ecological site – GLOBE (http://www.globe.gov/), Journey North (http://www.learner.org/jnorth/) and Lain (http://lain.atm.ncu.edu.tw/). Developing a PBL e-learning platform should incorporate the following functions: upload/download (web type, FTP type), online learning schedule (for exploring related activities), browse/search tools (web type, for peer review and evaluation), discussion board (interaction between peers and experts), visualized tools (maps and satellite images). Therefore, based on a needs analysis of users, the proposed PBL platform is constructed to provide various functional modules for instructors, experts, and students. Figure 1 presents the basic framework of a PBL e-learning platform.

Organizing PBL courses poses a challenge to instructors owing to the potential complexity of a project.
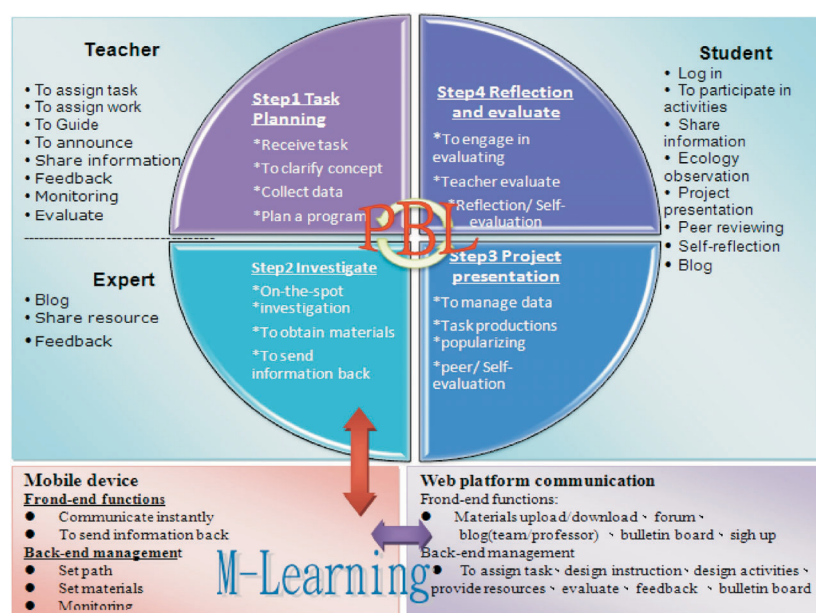

Figure 1. The framework of PBL e-learning platform.

In order to help instructors to design their instructional activities and guide students much easier to use PBL e-Learning platform, we conducted the PBL instructional steps [11,12] into PBL platform system.

Step 1: Plan the learning tasks. Students should confirm assigned learning tasks and relevant information with group members. Data should then be collected and project planning finalized through group interaction.

Step 2: Explore related topics. According to Step 1, students should explore related topics with mobile technology. Students can interact with each other in terms of real-life situations and learning information by communicating through mobile devices and the PBL platform.

Step 3: Present the project findings. Students should compile the information collected, and present the task results in PBL platform.

Step 4: Reflect up and evaluate the project findings. Students and teachers evaluate project findings on the PBL platform through self-assessment, peer assessment and teacher evaluation.

4.2 Infrastructure Design

This work presents a novel mobile learning system that integrates a PBL platform for teaching and learning. Using this platform, instructors can design learning tasks and activities based on real world situations, while students can access the platform through wireless mobile devices to interact with peers or instructors immediately.

Students can upload collected data and updated information stored in the platform database without time constraints. Additionally, the PBL platform connects to a mobile device supported by a GPS system. Students can thus pinpoint the location where they determine to explore and update the latest information throughout the learning process, during which, instructors can monitor student progress. Figure 2 presents the architecture of the proposed mobile learning system.

Based on the above user requirements, the proposed PBL platform and mobile system are developed using Microsoft Windows 7 OS, in which the server uses Apache Web Server 2.2.8 and database management system is MySQL 5.0.5lb. The PBL platform language is written using PHP5.2.6 and supported by several languages, such as JavaScript, CCS and AJAX. Most po-

pular browsers, including Microsoft Internet Explorer, Google Chrome, and Mozilla Firefox, support this PBL platform. The mobile system is developed using JAVA and Flash.

4.3 Mobile Learning Device Design

The PBL project in this work involves students exploring the outdoors. Notebooks (Eee PC by ASUS (Taiwan)) are selected as the mobile devices. A notebook computer is used to communicate with the PBL platform. Students can also use wireless laptop computers and interact with peers or instructors immediately via the PBL platform. Additionally, the positions and exploration paths of students are monitored using GPS. Instructors can determine the positions of students and communicate with or provide feedback to them immediately.

The proposed mobile system operates with a notebook computer and GPS. When students enter a particular scene, the mobile system embedded in their notebook computers updates them on their current GPS position and sends that information to the database. Moreover, instructors can use the PBL tracking system to monitor the location and movement of students or groups. Figure 3 indicates that the moving position is identified using GPS to locate the student's coordinates and post them on Google Maps.

From these maps, instructors can locate the students from Google Maps and also recognize the surrounding environment. The GPS system also connects to student's PDAs and cell phones. When students take a picture and upload it to the server, the metadata includes a precise location and coordinate settings. In addition to helping stu-
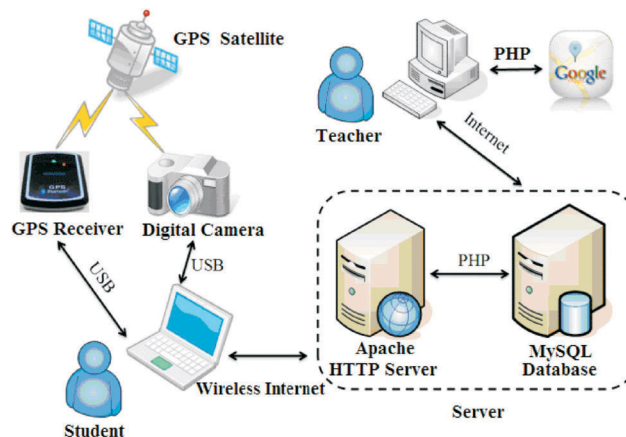

Figure 2. Mobile learning system architecture.

Figure 3. Mobile system integrates with Google map.

dents to complete their assigned learning task, this feature also provides instructors with solid evidence of student progress.

To handle the mobile and GPS functions efficiently, students also use a digital camera with GPS functions to collect scene data directly via the camera connects with the GPS system, subsequently allow them to label the data source automatically.

5. Experimental Study

5.1 Instructional Design of PBL Activity

Fifty nine university students enrolled in an e-learning course in a northern Taiwan university participated in the study. Knowledgeable in PBL strategy and e-learning, the course instructor was responsible for designing a PBL instructional plan. The experiment was conducted over an 8-week session. Students were assigned to 10 groups, with each one having a well-trained teaching assistant whom was familiar with the PBL process and mobile technology to facilitate student learning. Table 1 lists the detailed contents of the instructional plan.

5.2 Design of Outdoor Exploration Activity for Mobile Learning

The PBL exploration activity involved two school fieldtrips to visit the Mangrove Museum near the Tamsui River in northern Taiwan.

5.2.1 Visit to the Mangrove Museum

Students were oriented on the Mangrove wetland ecological environment through a video presentation and supplementary information from the museum guides.

5.2.2 Visit to the Mangrove Wetland Ecological Region

While venturing outside the museum to observe the growing mangrove wetland ecology environment, the participating students used mobile technology devices to locate pertinent information to complete their assigned tasks. As the wetland ecology issues addressed in their PBL earlier steps, students took pictures with digital cameras, discussed with peers, and uploaded their observation sheets to the PBL e-learning platform via wireless mobile devices.

6. Student Perceptions on Integrating PBL with Mobile Learning

Two questionnaires with a 5-point Likert scale that ranged from 1 (totally disagree) to 5 (totally agree) were administered to determine student attitudes towards the PBL activity, the mobile learning experience and their satisfaction levels.

Forty six of the 59 participants returned the PBL activity questionnaire, or a response rate of 77.97%. Thirteen questionnaires were discarded since they were only partially completed. Similarly, fifty four of the 59 par-

Table 1. Instructional design of PBL activity (exploring "the Mangrove Wetland Ecology")

PBL Steps	Instructional steps of PBL activity	Time
Step 1: Plan the learning tasks	● **Define problems and tasks** Students are able to (1) conduct a topic with depth and breadth. (2) clarify the goals of task. (3) discuss related subject issues. (4) The discussion topic has shifted into the core theme. ● **Develop a plan** Students are able to (1) Write project proposal documents, including the project objectives, production types, time schedule, learning content analysis, each group member's task. (2) discuss the project schedules with group members.	2 weeks
Step 2: Explore related topics	● **Research and collect information** Students are able to (1) collect the information relevant to the subject, and explain how to gather. (2) analyze further information, and retrieve the key information required for project.	1 week
	● **Investigate and implement** Students are able to (1) go outdoor to explore. (2) observe the mangrove wetland ecology environment and record it. (3) discuss with the group members and use mobile technology to gather raw data based on project's needs. (4) review the previous plan and the observed data and revise.	1 week
	● **Provide feedback and revise** Students are able to (1) edit and organize data. (2) summarize all the information related with the task. (3) screen out/remove unrelated information and retrieve effective content. (4) produce the ecological multimedia productions.	2 weeks
Step 3: Present the project findings	● **Present the project** Students are able to (1) present their projects. (2) process peer assessments (between and within group).	1 week
Step 4: Reflect up and evaluate the project findings	● **Reflect up and evaluate** Students are able to (1) Evaluate the products' qualities after they have done their projects. (2) do the reflective thinking.	1 week

ticipants returned the mobile learning questionnaire, or a response rate of 89.83%. Few respondents (20%) were aware of m-learning before the survey, with 10% having participated in m-learning previously.

6.1 Student Attitudes towards the PBL Activity

Attitudes towards PBL questionnaire were evaluated based on subscales adopted from Yang et al. [19]. Also, the Crobach's alpha coefficient of the PBL questionnaire in this study was 0.89, i.e. a satisfactory level of reliability. The average mean score of the PBL perception questionnaire is 3.67.

Table 2 ranks the top three items sequentially based on a mean score as items 8, 7, and 4. This finding suggests that students were confident in the ability of PBL to enhance their analytical skills, information searching skills, and discussion skills.

Meanwhile, Table 3 ranks the lowest three items se-

quentially based on a mean score as items 14, 2, and 5. This finding suggests that students did not feel strongly that PBL could promote their interpersonal relations, improve their learning motivation, and that the PBL should be used in future courses. Overall, students had a positive attitude towards the PBL activity.

6.2 Student Perceptions towards Mobile Learning

Attitudes towards mobile learning questionnaire were evaluated based on 6 subscales, was adopted from Wang et al. [20]. Also, the Crobach's alpha coefficient of the mobile learning questionnaire in this study was 0.925, i.e. a satisfactory level of reliability. Table 3 summarizes those results.

The average mean score in the "Social Influence" subscale was 3.528. This finding suggests that most of the students agreed that school administrators, instructors or peers influenced their use of mobile technology for learning. The average mean score in the "Effect Expectancy" subscale was 3.402. This finding suggests that most of the students agreed that using mobile technology

is relatively easy. Notably, the mean scores of "Behavioral intention to use m-learning" subscale (M = 3.208) and "Perceived playfulness" subscale (M = 3.223) were lower than those of the other subscales. Based on our observations, students in this experiment study needed to spend additional time to learn many new devices and complete their exploratory tasks in 8 weeks than what they had originally expected. We speculate that this factor may influence student willingness to use mobile learning. Still, above analysis results suggest that students still tend to have positive feelings towards mobile learning.

7. Conclusion

Despite the numerous studies on PBL effectiveness in a traditional classroom setting, the effectiveness of PBL instruction with a mobile learning system has seldom been addressed. This work presents a novel framework in which PBL is integrated in mobile learning and related instructional design activities. In addition to eas-

Table 2. Students' attitude towards PBL activity

Variable (N = 46)	α	M	SD
8. I think PBL can enhance my analysis capabilities	0.894	4.087	0.463
7. I think PBL can improve my information searching skills	0.894	4.022	0.614
4. I think PBL can promote my group discussion ability	0.89	3.826	0.851
1. I think PBL can help develop my thinking skills	0.892	3.804	0.582
9. I think PBL can improve my communication ability	0.886	3.761	0.822
6. I think PBL can facilitate mutual collaboration	0.892	3.739	0.855
11. I think PBL can foster my problem solving skills	0.887	3.739	0.88
10. I think PBL can help me to utilize the knowledge	0.89	3.696	0.813
12. I think PBL can enhance my future learning	0.892	3.609	0.856
13. I think PBL can help me to learn the important subject knowledge	0.893	3.609	0.930
3. I think PBL can facilitate my active learning	0.888	3.500	0.810
5. I think PBL can promote my interpersonal relationship	0.89	3.478	0.937
2. I think PBL can enhance my learning motivation	0.89	3.326	0.732
14. I will suggest that the course could continue to use the PBL in the future	0.897	3.283	0.981

Table 3. Students' perceptions towards mobile learning

Variable (N = 53)	α	M	SD
Social influence	0.907	3.528	0.664
Effect expectancy	0.909	3.402	0.744
Performance expectancy	0.895	3.366	0.754
Self-management of learning	0.883	3.338	0.604
Perceived playfulness	0.916	3.223	0.763
Behavioral intention to use m-learning	0.913	3.208	0.865

ily accessing friendly interface guides to design instructional mobile projects via the PBL platform, instructors can also easily monitor the status of student learning by using the PBL platform and mobile learning system. Hopefully, implementing the proposed PBL strategy with mobile learning will increase the receptiveness among instructors and university students to increase their learning based on information technology approaches. Meanwhile, the PBL learning method of analysis, synthesis, application, participating, communication, and collaborative learning is cultivated for students.

Six students interviewed based on random selection from the study group expressed the excitement of completing the PBL exploratory project during a 8-week session. Moreover, due to speed restrictions of wireless Internet mobile devices, students had difficulty in uploading and downloading data from the PBL e-learning platform, as well as using mobile technology while they were outside exploring. However, analysis results indicate that following exposure to the proposed PBL e-learning system with mobile technology, students had an overall positive attitude towards PBL activities and mobile learning.

To construct an environment that can support different PBL activities, efforts are already underway to conduct usability tests for the PBL e-learning platform in order to provide a more user friendly learning environment for both instructors and learners. Moreover, with the comprehensively designed PBL e-learning platform, m-learning devices and instructional design, PBL exploratory activities will be much easier to implement for students. Efforts are also underway to examine learning achievement among students as to whether they make progress on learning tasks (content knowledge) via PBL instruction with mobile learning.

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References

[1] Milentijevic, I., Ciric, V. and Vojinovic, O., "Version Control in Project-Based Learning," *Computers & Education*, Vol. 50, pp. 1331–1338 (2008).

[2] Köse, U., "A Web Based System for Project-Based Learning Activities in "Web Design and Programming" Course," *Procedia - Social and Behavioral Sciences*, Vol. 2, pp. 1174–1184 (2010).

[3] Eskrootchi, R. and Oskrochi, G. R., "A Study of the Efficacy of Project-Based Learning Integrated with Computer-Based Simulation-Stella," *Educational Technology & Society*, Vol. 13, pp. 236–245 (2010).

[4] Downing, K., Kwong, T., Chan, S., Lam, T. and Downing, W., "Problem-Based Learning and the Development of Metacognition," *Higher Education*, Vol. 57, pp. 609–621 (2009).

[5] Krajcik, J. S., Blumenfeld, P. C., Marx, R. W. and Soloway, E., "A Collaborative Model for Helping Teachers Learn Project-Based Instruction," *Elementary School Journal*, Vol. 94, pp. 483–497 (2010).

[6] Peterson, S. E. and Myer, R. A., "The Use of Collaborative Project-Based Learning in Counselor Education," *Counselor Education & Supervision*, Vol. 35, pp. 150–158 (1995).

[7] Curtis, D., "The Power of Projects," *Educational Leadership*, Vol. 60, pp. 50–53 (2002).

[8] Gultekin, M., "The Effect of Project Based Learning on Learning Outcomes in the Fifth-Grade Science Education," *Elementary Education Online*, Vol. 6, pp. 93–112 (2007).

[9] Simkins, M., "Project-Based Learning with Multimedia," *Thrust for Educational Leadership*, Vol. 28, pp. 10–13 (1999).

[10] Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M. and Palinscar, A., "Motivating Project-Based Learning Sustaining the Doing, Supporting the Learning," *Educational Psychologist*, Vol. 26, pp. 369–398 (1991).

[11] Gi, H.-Q. and Chang, S.-F., "All Dimensional Learning Strategies: Project Based Learning Design," *Instructional Technology and Media*, Vol. 55, pp. 58–71 (2001).

[12] Zhou, H.-Y., "Learning project in courses, teaching and evaluation", *Tainan Normal College Report*, Vol. 34, 155-194 (2001).

[13] Motiwalla, L. F., "Mobile Learning: A Framework and Evaluation," *Computers & Education*, Vol. 49, pp. 581–596 (2007).

[14] Lan, Y.-F. and Sie, Y.-S., "Using RSS to Support Mobile Learning Based on Media Richness Theory," *Computers & Education*, Vol. 55, pp. 723–732 (2010).

[15] Sharples, M., Taylor, J. and Vavoula, G., "Towards a Theory of Mobile Learning," *Proceedings of MLearn 2005 Conference*, Cape Town (2005). Available online at http://www.mlearn.org.za/CD/papers/Sharples-%20Theory%20of%20Mobile.pdf.

[16] Chang, C. Y., Sheu, J. P. and Chan, T. W., "Concept and Design of Ad Hoc and Mobile Classrooms," *Journal of Computer Assisted Learning*, Vol. 19, pp. 336–346 (2005).

[17] Wu, M.-R., "Development and Design of Mobile Learning Environment for Interactive Discussion Project," *Master Thesis*, National Taiwan Normal University, unpublished (2005).

[18] Sancho, P., Moreno-Ger, P., Fuentes-Fernández, R. and Fernández-Manjón, B., "Adaptive Role Playing Games: An Immersive Approach for Problem Based Learning," *Educational Technology & Society*, Vol. 12, pp. 110–124 (2009).

[19] Yang, K.-Y., Chang-Lai, M.-L., Chen, M.-W. and Hsu, T.-L., "The Effectiveness of Implanting PBL Strategy in K10 Students' Science Course," *Republic of China 22nd Science Education*, 2006 December 15-16, Taipei (2006). (in Chinese)

[20] Wang, T.-S., Wu, M.-C. and Wang, H.-Y., "Investigating the Determinants and Age and Gender Differences in the Acceptance of Mobile Learning," *British Journal of Educational Technology*, Vol. 40, pp. 92–118 (2009).