

The influence factors for improving ubiquitous outdoor learning

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Abstract. This study explores how information technologies, interaction, learner control, and the learning model can improve outdoor natural science learning, based on student feedback by using a ubiquitous learning environment. To address such concerns, this work used an environment of ubiquitous learning with educational resources (EULER) for natural science learning at a wetland in Taiwan. EULER helps teachers deliver lessons on site and cultivate student competency in adopting novel information technology and appropriate learning strategies to assist outdoor learning. The participants were elementary school teachers and students. During the experiment, a survey, and interviews were conducted for the students. The analytical results revealed that using appropriate information technologies, interaction, learner control, and the learning model could improve student outdoor learning.

Keywords: augmented reality, natural science, sensors network, ubiquitous learning

1. Introduction

The learning effect of computer-based learning environments continues to be an important research topic. Webster and Hackley argued that quality, reliability, and ease of use of information technologies influence their effectiveness for learning [1]. Webster and Hackley concluded that the most effective learning methods should include rich media, student-instructor interaction, and instructors who project positive attitudes [1]. Piccoli, Ahmad, and Ives found that students with experience using technology and who have positive attitudes about technology tend to perform well in virtual learning environments [2]. Leidner and Jarvenpaa stated that technologies promoting communication and interaction are effective for developing higher-order thinking skills and building conceptual knowledge when following a constructivist or collaborative learning model [3]. Wells stated that technologies promoting participant communication are best suited for subject matter or course designs that emphasize discussion, brainstorming, problem-solving, collaboration, and reflection [4]. Milheim and Martin defined three types of control that a learner may have, namely, learning pace control, learning sequence control and learning content control [5]. Learning pace control refers to the speed at which course themes are presented. Learning sequence control refers to the order in which course themes are presented. Learning content control refers to the ability of learners to omit content themes with which they are already familiar. Giving learners some control over course components enhances the effectiveness and efficiency of learning environments according to a literature review by [6]. Piccoli, Ahmad, and Ives defined interaction as “the degree of contact and educational exchange among learners and between learners and instructors.[2]” The interactive teaching style is positively related to learning outcomes [1], control of the technology and technology attitudes [3], self-efficacy, and initial motivation. Piccoli, Ahmad, and Ives stated that students in highly interactive instruction may experience reduced isolation frustration, anxiety, and confusion, and gain positive learning effectiveness [2].

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Given that previous studies asserted that the learning model affects the learning performance of students, this study explores how information technologies, interaction, learner control, and the learning model can improve outdoor natural science learning, based on student feedback by using EULER.

2. Methodology

A series of controlled experiments were conducted using the EULER in indoor and outdoor learning for fifth-grade students. After completing the experiments, an interview was taken to know what influence for outdoor learning.

2.1. Participants

The study included the cooperation of the Affiliated Experimental Elementary School of Taipei Municipal University of Education. Participants included four natural science teachers and 36 students. Four teachers had at least ten years of experience in computer-assisted instruction.

2.2. System

The EULER consists of two subsystems: the Mobile Interactive Learning Environment (MOBILE) server for teacher's usage, and the provision of mobile-tools (m-Tools) for students, respectively [7, 8]. In the case of the outside classroom, teachers can use computer notebooks installed with the MOBILE server to conduct outdoor teaching. Before teaching, teachers can install teaching materials into the Mobile Content Database (MCDB) and establish assessments in the Mobile Assessment Database (MADB). In the course of teaching, the MOBILE server addresses requests from and responses to students. The Learning Activity Management (LAM) unit constructs a virtual classroom and supports many learning activities, including bulletin boards, forums, voting, chatting, homework, assessment and instruction. After completing outdoor teaching, teachers can conduct tests through a Mobile Assessment Management (MAM) unit and analyze student performance. Student learning statuses and records are saved in the Mobile Learning Record Database (MLRDB). The MLRDB stores student's records, which include assignment grades, reading times, number of discussions, instances of data collection, and instances of information sharing.

The m-Tools is built on PDA. It has many functions, including enhanced m-RFID and m-AR tools. The User Interface (UI) coordinates each tool and stores learning records in the Mobile Database (MDB). When a student using a PDA on a visit to a zoo, for example, observes an exhibition equipped with an RFID tag, the RFID reader on the PDA detects the internal code of the tag, and then the m-RFID sends this code to the EULER server, which in turn downloads context-aware content to the PDA. The student then uses m-Player to immediately browse the contents. Simultaneously, the m-Player updates the MDB with the material read by the learner. Additionally, student uses m-Messenger to receive teacher guidance, uses m-Capture to record animal's active videos, and uses m-Loader to access additional materials from the EULER server. Later, student can use m-Notes to compile collected information into articles, and then utilize m-Sharer to send articles to the team leader via wireless local area network (WLAN). The team leader can organize those articles, compile into a team report, and then sends report to the teacher by using m-Notes. Through the m-AR, students can virtually see creatures that they do not normally see in the real world. Fig. 1 illustrated the system architecture.

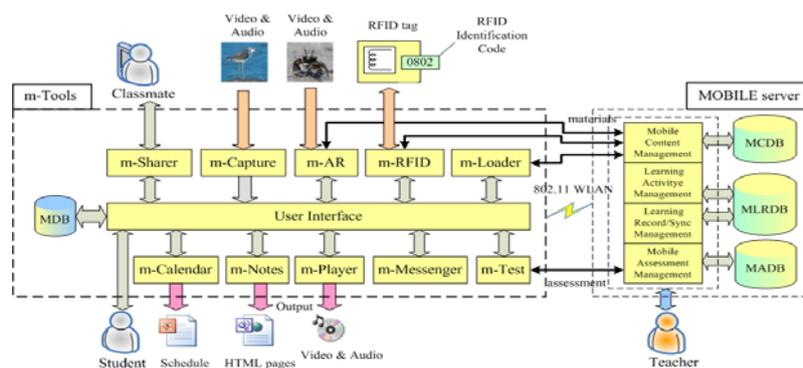


Fig. 1 Structure of EULER

2.3. Procedure

Taiwan's wetlands include many creatures worthy of exploration and analysis, and thus we chose this topic for study, entitling the course "Taiwan Ecosystems." We adopted Problem-Based Learning (PBL) as a pedagogic strategy, designating the problem "How can the gradually disappearing wetland ecosystems in Taiwan be protected and restored?". The advantages of PBL over traditional teaching methods have been well documented and include improving self-directed learning, increasing self-motivated attitudes, fostering problem-solving abilities and enhancing knowledge-application skills [9]. The learning goals of this course included: 1) Understanding the natural environment and creatures in wetlands; 2) understanding the importance of wetlands; 3) understanding the relationship between creatures and environment; and 4) understanding the concept and manner of wetland ecology protection.

In outdoor teaching, teachers first assigned a team problem-solving project and conducted a treasure hunt game, and an immersive learning activity at Guandu Nature Park. Teachers employed notebooks installed with the MOBILE server to conduct learning activities. Each student used a mobile learning device installed with m-Tools to perform the learning activities. Teachers prepared a number of information boards, with an RFID tag attached to each board. Teachers then established the relationship between learning materials and the identification codes of RFID tags, and placed the information boards along with the corresponding wetland creatures. Students carried a mobile device equipped with a video camera and an RFID reader when visiting scenic spots using the treasure map. When students approached a scenic spot, they could use the learning device to detect the RFID tag attached to the information board. The detected identification code of the RFID tag was then sent to the teacher's MOBILE server via WLAN. The MOBILE server recognized the location of student, and then sent the context-aware contents to the student's learning device. When students completed a learning unit at one scenic spot, they answered a question and then went to the next scenic spot until all scenic spots had been visited. The team that first completed the game was given an award. In this way, students accessed context-aware contents related to real creatures, enabling context-aware ubiquitous learning.

Moreover, the title of one of the team projects was "How to restore wetlands?" Through group discussions, students still could not propose any substantial method. Therefore, students used the m-Messenger to send a message to the teacher asking for assistance. Under the guidance of the teacher, team members used m-Capture to capture images or videos of the restoration projects currently being implemented in the wetlands, and retrieved relevant information from the MOBILE server. This was then compiled into articles. These articles were then transmitted to team leaders in order to create a rich team project report, which was submitted to teachers via WLAN. Fig. 2 illustrates examples of learning activities. After all students had completed their outdoor learning activities and submitted their team project reports via m-Share, teachers featured outstanding reports via the MOBILE server to each group. These outcomes were evaluated by peer groups and teachers. In the immersive learning activity, students used the m-AR to see virtual creatures that students may not see normally in the wetland. For example, student could see virtual mandarin ducks swim on a stream.



Fig. 2 Snapshots of outdoor learning.

3. Results and Discussion

A questionnaire was administered to students at the end of the learning activity. All 36 of the questionnaires distributed were valid, which was a 100 percent response rate. Table 1 lists the survey results, based on a 5-point Likert scale. The responses to item A1 indicated that most students thought that the m-Tools were easy to use ($m = 3.83$). One student stated, "I wanted to know whether crabs all move sideways. I

found that one of the species called the soldier crab (*Mictyris brevidactylus*) is an exception. Using these ubiquitous learning tools, I could acquire new knowledge easily.” The responses to item A2 indicated that the system functions were convenient and sufficient for learning ($m = 3.86$). Most students considered PDAs to be novel devices, and opined that such learning experiences would not be possible without the handheld devices. The responses to item A3 indicated that most students effectively used the m-Tools to collect, share, and analyze data, and further complete reports ($m = 4.02$). Many students indicated that using modern devices when learning outdoors is a diverting experience. The responses to item A4 indicated that most students thought that the screen size of the PDA was too small ($m = 3.02$). A larger screen would enable them to read the content easily. The responses to item A5 indicated that most students considered the audio quality of PDA inadequate ($m = 3.28$), such that they could not listen to materials clearly.

Item B1 indicates that students gained much more knowledge by using m-RFID than by using worksheets ($m = 4.32$). One student stated, “I could not only read webpage-based materials at any time, but could also watch biological creatures closely.” Item B2 indicates that students could collect more information by using m-Loader and m-Capture ($m = 4.12$). One student stated, “I used m-Capture to capture some valuable photos and films. Many of my classmates were very jealous of me after they saw the photos and films.” Item B3 indicate that most students thought that the m-Sharer could help them share information with classmates ($m = 4.02$). Item B4 indicates that most students thought that m-Notes could help them complete common projects collaboratively ($m = 4.06$). One student stated, “Our group used m-Share to transfer the animal data that we gathered to the leader. After the leader prepared a report, he shared it with all the group members.” Results B1, B2, B3, and B4 reflect the ability of EULER to enable students to search, collect, share, and edit information further to improve learning.

Table 1. Summary of survey results from 36 students (5-point Likert scale)

Item	Mean	SD
A. Information technology		
A1. The user interface of the m-Tools is friendly.	3.83	0.78
A2. The system functions of the m-Tools are convenient.	3.86	1.12
A3. I am familiar with using m-Tools to collect, share, and analyze data, and to further compile them to a report.	4.02	0.71
A4. The PDA display is sufficiently clear for reading learning content.	3.02	1.22
Learner control		
B1. Applying the m-RFID to outdoor learning helps me gain real knowledge.	4.32	0.64
B2. Applying the m-Loader and m-Capture to outdoor learning helps our team in collect information.	4.12	0.77
B3. Applying the m-Sharer to outdoor learning helps our team to share information.	4.02	0.86
B4. Using m-Notes for outdoor learning helps our team complete assigned project collaboratively.	4.06	0.84
Interaction		
C1. Using the m-Capture increases interaction with the natural environment.	4.22	0.74
C2. Using the m-Messenger increases interaction with teachers.	4.13	0.76
C3. Using the m-Loader and m-Notes increases interaction with computers.	4.22	0.69
C4. Using the m-Sharer increases interaction with classmates.	4.17	0.80
Learning model		
D1. I enjoy the problem-solving learning activity because it enables me to understand the importance of wetland ecology protection.	4.12	0.77
D2. I enjoy the treasure-hunt game because it makes outdoor learning interesting.	4.25	0.82
D3. I enjoy the immersive learning activity because it enables me to watch virtual creatures in the actual natural environment and to learn about wetland wildlife.	4.33	0.72
D4. I enjoy the RFID-based ubiquitous learning environment, which is similar to a natural museum.	4.22	0.74

The responses to item C1 indicated that most students thought that using the m-Capture could increase interaction with natural environment ($m = 4.22$). One student stated, “I used the image-capturing tool (m-

Capture) to take snapshots of animals that I observed.” Responses to item C2 indicated that most students thought that using the m-Messenger increased interaction with teachers ($m = 4.13$). Responses to item C3 indicated that most students thought that employing the m-Loader and m-Notes increased interaction with computers ($m = 4.22$). Many students commented that they were highly motivated to use modern devices such as PDAs. Responses to item C4 indicated that most students thought using the m-Sharer could raise interaction between classmates ($m = 4.17$). Results C1, C2, C3, and C4 also replied to the issue, illustrating the ability of EULER to motivate students in learning and improve learning.

Responses to item D1 indicated that most students enjoyed the problem-solving activities and understood the importance of wetland ecology protection ($m = 4.12$). One student replied that household wastewater, industrial wastewater, and agricultural chemicals all eventually flow into rivers. Responses to item D2 indicated that most students found that the multimedia learning materials and the on-site treasure hunt game added interest to the learning process ($m = 4.25$). One student said, “I saw fiddler crabs waving fiddle claws and waterbirds looking for foods beside the pond. I could also reach out my hands to touch the *Kandelia* candle.” Responses to item D3 indicate that most students observed many creatures that they had never seen before ($m = 4.33$). Many commented that they enjoyed watching virtual creatures on PDAs. One of them stated, “Through the m-AR function of the PDA, I could see a virtual *Uca lacteal* waving its fiddle claws on the swamp.” Responses to item D4 show that most students regarded EULER as a natural science museum ($m = 4.22$). One student stated, “When I walked into a learning area, the RFID sensor device on my PDA could detect my location and tell the PDA to download relevant materials for me.” Result D4 also replied to the issue, illustrating the ability of students to attain museum-like learning experiences in learning.

4. Conclusions

This work demonstrates that RFID and AR technologies provide museum-like learning experiences in context-aware, immersive, and ubiquitous learning activities. The survey results indicated that EULER provides convenient functions and diverse educational applications for teachers; students can learn flexibly and independently at any time and place. Most students thought EULER easy to use, and most believed it could assist their learning. Further, the results reveal that, compared to traditional learning methods, the EULER not only increases the motivation of students to learn and improves the effectiveness of learning, but it also improves student creativity and the ability to explore and absorb new knowledge and solve problems. Moreover, educators can benefit from the inclusion of educational objectives of acquisition of authentic knowledge, development of the sense of cooperation, training of problem-solving ability, improvement of learning motivation, stimulation of imagination, and creativity in future learning activities.

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