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Developing a Mobile Learning Environment Based on Augmented Reality Technology

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Abstract: In this study, we establish a mobile learning system with the technology of augmented reality. A theoretical framework of learning by experience is applied to interpret findings. We conclude that three themes of interaction and conversation, double-loop learning, and technology supports have a major impact on students learning performance.

Keywords: Mobile learning, augmented reality, learning by experience

Introduction

An up-to-date report mentions that mobile devices have been widely used for more than 4 billion subscribers [1]. More and more individuals use software application, with augmented reality technologies, in mobile camera-screen devices to explore interesting subjects under study. This advantage provides an opportunity for learners to identify the subject and its relationship with context. Moreover, by participating in a real world, students are able to experience in authenticity and relate those findings with the surroundings that enriches their understandings.

There is a lack of mobile learning environment with augmented reality to help students learn from an authentic world. Furthermore, researchers lack of knowledge about students' learning effects based on the idea of learning by experience.

This study has established a mobile learning environment supported by augmented reality technology. Additionally, we used this developed system to investigate students' learning effects supported by a theoretical framework of Kolb [2].

Literature Review

We believe that mobile learning provides learners with great opportunities to learn with experience. While participating at authentic context, learners use the technology of augmented reality to help them to discover the unknown. To better understand related articles researched, the following sections of (1) learning by experience, (2) mobile learning, and (3) augmented reality is discussed.

1. Learning by experience

Learning by experience refers to learn through experiencing the reality and transforming experience. The goal of learning by experience focuses on help learners more deepen understanding the learning topics related to context than merely understand preexisting facts [3]. A key element of learning by experience emphasizes the needs of reflecting on their findings from learner experience [4]. To obtain own knowledge, Awad and Ghaziri [5] argue

that learners need to share their understandings and make own meaning while experiencing the learning topics.

Nonaka and Takeuchi [6] argue that learners adapt learning strategy to learning by experience help them enrich an individual experience and obtain own knowledge. Furthermore, learners need to learn from concrete experience, reflective observation, abstract conceptualization, and active experimentation to implement the transformation of experience [2] and creation of knowledge [7].

Furthermore, Kolb [2] provides a conceptual underpinning of learning by experience from four different dimensions that help researchers evaluate its effectiveness. We focus on the "learning styles" component, which is an actual learning activity, as a theoretical framework to support this study (see Figure 1).

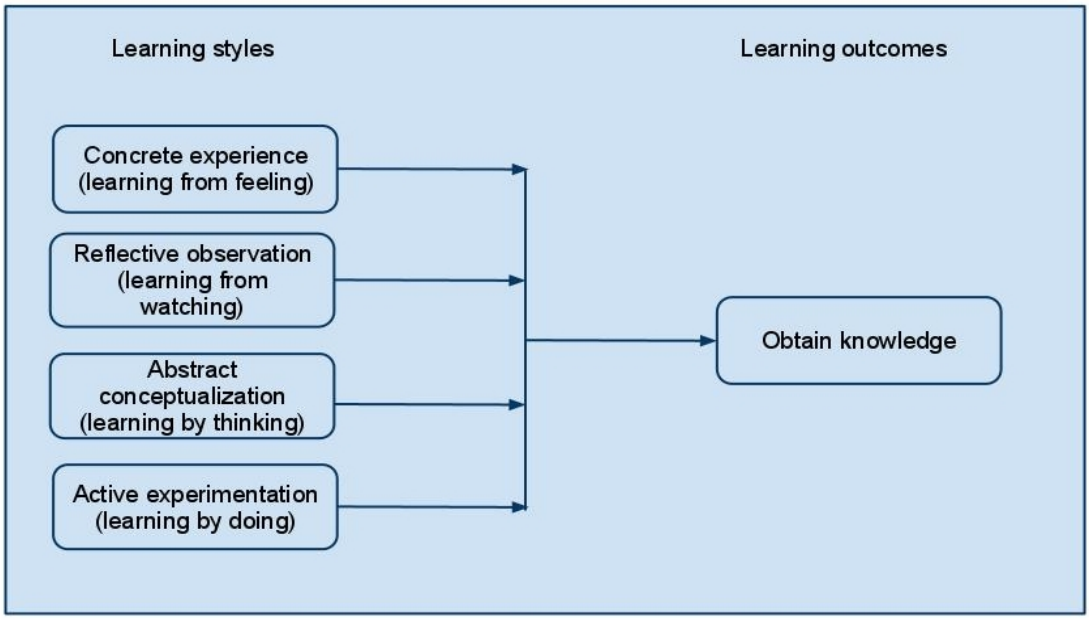

Figure 1: A description of four learning styles of learning by experience as related to students' achievement and this study inspired by Kolb [2]

The idea of experiential learning suggests students to obtain knowledge beyond the limits of indoor classroom activities [8]. Nowadays, mobile phone has been widely used for information collection and for sharing ideas anywhere and anytime.With the help of innovative technology, mobile learning provides learner opportunities to obtain knowledge in an authentic context.

2. Mobile learning

Mobile learning is learning that occurred when the learner applies mobile technologies in learning activities. Mobile learning, through the use of camera-screen and Internet connection, facilitates students to construct their learning experience by instant interaction with learning subject and other learners [9]. On the benefits of mobile technology innovation, learners are able to interacting with learners and soundings at anywhere and anytime to construct own knowledge [10].

The GPS function, a location-aware function embedded in a mobile device, provides learner opportunities to identify the subject under study. With the application of GPS technology, students are able to grasp information from the database based on the students'

locations to explore findings and then apply understandings for future research. Additionally, the integration of camera-screen and GPS provides a bridge between the physical and digital worlds that help learners identify the learning subject and understand a broad context.

The application of the mobile device, integrated with wireless and software resources, becomes a tool for study and survey. An annual report suggests a mobile phone with an application of augmented reality has growing tendencies that help students to learn in authentic worlds [1].

3. Augmented reality

Augmented reality (AR) is a system that applies virtual computer-generated information in live view of the surrounding real world of the user as a way to supplement the physical real-world environment [11][12][13]. The theoretical sources of AR come from Milgram and Kishino's Reality-Virtuality Continuum [14] and Mann's Mediated Reality Continuum [15]. This framework considers that reality may be modified by devices in various ways, deliberately or accidentally. As a result, the technology potentially enhances one's current perception of reality.

Augmented reality combines reality and virtuality to demonstrate an information layer on top of the user's real world view. To accomplish this combination, AR system needs the hardware devices to identify the users and the objects in the physical context. Modern AR systems use one or more of the following technologies to recognize the user and the object, such as magnetic, ultrasound, inertial, accelerometer, UWB, optical, GPS, Wi-Fi, and hybrid [16]. The user's pose and position can be tracked to provide a three-dimensional interaction with the objects for the augmentation of the user's view. With the help of the head mounted or spatial displays, users can have immersive experience and collaborative work from the AR systems. However, the cumbersome hardware components are not satisfied with the requirements of portability and ubiquitousness for current AR applications.

Recent advances in mobile computing have enabled a new type of augmented reality systems and applications. Mobile AR systems employ a small computing device with digital cameras, GPS, gyroscopes, and solid state compasses that often fits in a user's hand. Most mobile AR machines adopt video see-through techniques to overlay the graphical information to the physical world. Machines that fit the user's environment, instead of forcing users to enter theirs, help overcome the problem of information overload [17]. Current mobile AR applications have virtual character-based applications, cultural heritage, edutainment and games, navigation and path-finding, collaborative assembly and design, and industrial maintenance and inspection [18]. There are still important challenges confronted by mobile AR applications, which are limited computational resources, size and weight, battery life, ruggedness, tracking and registration, 3-D graphic and real-time performance, social acceptance and mobility, and networked media [18].

AR has been used in the field of business and education to create state of the art in knowledge transfer for learning. The marker-based augmented reality applications help students better understand learning concepts and make more effective and interaction [19]. However, wireless mobile AR systems expand students' experiences and interactions by infusing digital resources throughout the real world. This type of mediated immersion aids students' engagement and understanding through embodied participation [20].

Research methods

The goal of this study is to establish a reliable mobile learning environment for students to obtain knowledge. We conduct two methods to help us understand the usability of mobile

devices and the perceptions of students about their experience in learning activities. Two methods of: (1) implementing a mobile learning environment and (2) evaluating the effect of mobile learning based on a theoretical framework are described as followings.

1. Implementing a mobile learning environment

Mobile AR systems require many enabling technologies, including computing hardware, software, wireless network, tracking and registration, input and interaction devices, and displays. This study chooses the smartphone to demonstrate a mobile learning platform, because this handheld device combines powerful CPU, multi-touch and high resolution displays, digital camera, 3G networking, accelerometers, GPS, and solid state compass to a parsimony mobile AR equipment and frequently found in navigation and educational settings.

Mangrove ecology systems in Hsinfon area are the source materials that provide the content to be viewed in the AR browser (see Figure 2). Layar libraries are used to create the AR application. The Layar App combined with a mobile device allows the user to see the virtual objects augmented onto the screen of the real mangrove world. The Layar Developer API is used to create mangrove content layers and submit them via the Layar Provision Website to be added to the Layar service. A smartphone is required to test and demonstrate the application. The demonstration shows how location and objects recognition permits the real-time context to be augmented directly onto the screen. Observers are able to see for themselves how augmented reality visualization assists in their understanding of the mangrove ecology systems. Data collected from five learners have identified this as a highly portable, ubiquitous, and effective system, expected to be of great benefit for learning.

2. Evaluating the effect of mobile learning based on theoretical framework

This study use the framework of learning by experience provided by Kolb [2] to measure student achievement by using mobile phone embedded with augmented reality technology. A focused group study has conducted to investigate the feedback of students. Five college students are chosen to a selected location, where they have never been there before, to experience the learning topics. Open-ended questions have been asked and students are allowed to interact with others to answer the questions with paper-pencil. Data has transformed into text and typed into computer for analysis.

Figure 2: A picture of Mangrove environment through camera-screen of a mobile device with augmented reality.

Discussion

After data analysis from feedback of the focused group, three themes of (1) interaction and conversation, (2) double-loop learning, and (3) technology supports were found. Each theme is described at the following section.

(1) Interaction and conversation: Students find it is an interacting experience to interact with mobile device to retrieve information from a database for identifying learning subjects. Through conversation with each other, students are able to share their understandings and help them clarify findings.

(2) Double-loop learning: after the content investigation, one student has researched further on the Internet to discover deepen understandings related to learning topics. This effort also triggers other students to identify their previous beliefs and then transform their experience.

(3) Technology supports: Students use mobile devices to connect their thoughts with contents and experience of individuals that motivate them toward a desired outcome. When learners participate in an outdoor learning activity, mobile devices provide a better learning opportunity beyond limitations of traditional face-to-face classroom. With the help of mobile devices embedded with augmented reality technology, students are familiar with subjects under study as well as an extent their views on a related study to the surroundings.

Conclusion

We found the dynamic nature of knowledge creation in a mobile learning environment with augmented reality. The learning topics, supported by mobile learning environment, provide historical facts and guide students to identify contents and context. Moreover, students apply three learning strategies of interaction and conversation, double-loop learning, and technology that enrich their experience and transform knowledge for new understandings. With research further on new understandings, learners begin to plan on solving an incoming issue and justify their assumptions, this action led to a new loop of knowledge creation.

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