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Animating eco-education: To see, feel, and discover in an augmented reality-based experiential learning environment

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ABSTRACT

An antagonistic relationship is traditionally seen as existing between eco-education and technology, with conventional instructional approaches usually characterized by a commentator guiding students in field learning. Unfortunately, in this passive learning approach, the discovery of rich ecological resources in eco-environments to stimulate positive emotions and experiences is often condensed into a "sightseeing". Therefore, precise and systematic guidance focused on providing a rich learning experience is needed in field learning and eco-education. Based on Kolb's experiential learning theory, the current study develops an eco-discovery AR-based learning model (EDALM) which is implemented in an eco-discovery AR-based learning system (EDALS). In a field experiment at a botanical garden, 21 middle school students constitute three groups participated in a learning activity using different learning types and media. Quantitative results indicate that, compared to the human-guidance-only model, EDALS successfully stimulates positive emotions and improved learning outcomes among learners. In post-activity interviews, students indicated they found the exploration mode provided by the proposed system to be more interesting and helpful to their learning in school. The use of attractive technologies increase students' willingness not only to learn more about the environment, but also to develop a more positive emotional attachment to it.

1. Introduction

Modern economic and human development trends has increasingly created a polluted environment, thus highlighting the urgent need for ecological education. While many Asian countries stress ecological education, they perform poorly in instituting affective education (Chang, Chen, & Hsu, 2011; Gurevitz, 2000) and elementary and middle school ecological and environmental education is still carried out in classroom. This lack of real-world interactions and exploration makes it difficult for students to develop an emotional attachment for or interest in ecology, thus limiting their enthusiasm for practicing environmental protection (Hautecoeur, 2002). In addition, numerous studies of human interaction with real ecological environments have found that "emotion" is an important learning factor, but is frequently overlooked. Reis and

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Roth (2009) pointed out the importance of emotion in ecological environment education, and the problems that can arise when such emotion is lacking.

Botanical gardens help maintain plant diversity in urban areas and provide opportunities for learners to experience complex ecosystems. Rich ecological and learning resources make botanical gardens a suitable outdoor informal learning environment (Chang et al., 2014; Chiou, Tseng, Hwang, & Heller, 2010; Liu, Lin, Tsai, & Paas, 2012). However, traditional display cards at such gardens typically only render information via text or graphics, often providing only a very limited introduction to specific plants. This approach makes it provide the rich information learners need to truly explore their environment, and limits the learning effectiveness of outdoor teaching (Sommerauer & Müller, 2014). Although audio tours have become quite common in recent years, and provide users with more in-depth explanations than conventional signage, such systems still cannot provide systematic and interactive learning in outdoor learning environment (Chang et al., 2014). Theoretically, assistive technology that can provide learners with expanded access to practical real-world information could provide a more effective approach to implementing ecological educational activities in contexts such as botanical gardens.

The development of information technologies has led to many innovations in modern teaching and learning methods. Integrating new technologies into instruction allows teachers to transform learning materials from a fixed combination of texts and graphics into more interactive multimedia material. The integration of digital learning with convenient and fast internet technology has further lowered the barrier of differentiated teaching and helped to overcome time and space constraints in traditional teaching models, thereby moving students from the passive reception of knowledge to more active learning approaches (Liu et al., 2012; Mohammadyari & Singh, 2015). Smart phones and tablet computers have recently emerged as mainstream devices for use in mobile learning. Harris (2001) believed that the convenience and immediacy of mobile learning provides more learners with additional learning opportunities. Mobile learning allows teaching/learning to be carried out in authentic outdoor learning environments, providing learners with a broader range of opportunities to acquire knowledge. Moreover, authentic learning environments do more to evoke affective feeling than classroom learning environments (Gulikers, Bastiaens, & Martens, 2005; Sommerauer & Müller, 2014).

Given the limitations of real world education in ecological environments and regular disregard for emotion factors, this study uses botanical garden-based outdoor ecological learning as an experimental situation, integrating experiential learning theory to strengthen real-world exploration, and adopts augmented reality (AR) technology to create an mobile learning system to break through real-world information limitations, thereby exploring learning effectiveness and learners' emotional conversion process.

The present work designs and implements a coordinated actual and AR virtual action ecological learning system based on experiential learning theory. Furthermore, an AR system is developed to apply the experiential learning model to ecological education. In addition, this study examines the impact of learner emotion on experiential learning and learning performance using the AR action ecological learning system.

2. Literature review

2.1. Augmented reality in education

Milgram and Kishino proposed that the actual and virtual environment are on a continuum (Milgram's Reality-Virtuality Continuum, Fig. 1) and defined AR as a sort of display device that allows for the visualization of virtual objects in a real world environment. AR can be defined as any case in which an otherwise real environment is "augmented" by means of virtual objects (Milgram, Takemura, Utsumi, & Kishino, 1994). This technology allows users to interact with virtual images in real world contexts (Chen & Tsai, 2012). AR layers computer-generated sensory inputs such as audio, video, graphics or GPS data on a live direct or indirect view of a physical real-world environment (Wu, Lee, Chang, & Liang, 2013). Therefore, AR can provide image transfer information, using electronic devices to allow users to experience the integration of the real and virtual environments (Klopfer & Sheldon, 2010). Moreover, the use of visual interaction and operation can enhance the user experience (Dunleavy, Dede, & Mitchell, 2009). With the help of advanced AR technology, observers can digitize information in the surrounding real world and make them operable.

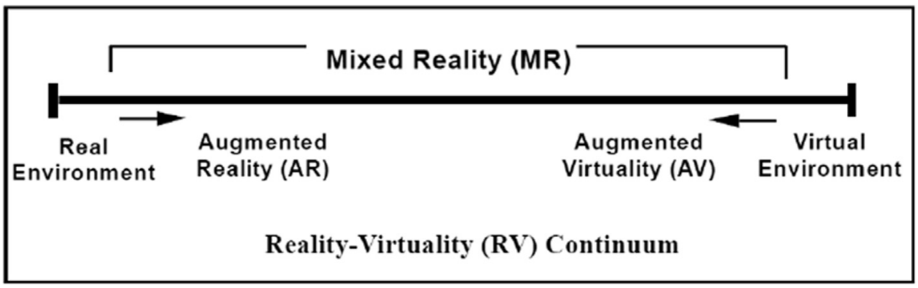

Fig. 1. Milgram continuum (Milgram et al., 1994).