Computers & Education 71 (2014) 185–197

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Development and behavioral pattern analysis of a mobile guide system with augmented reality for painting appreciation instruction in an art museum

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ARTICLE INFO

Article history:
Received 24 May 2013
Received in revised form
18 September 2013
Accepted 23 September 2013

Keywords:
Applications in subject areas
Architectures for educational technology system
Interactive learning environments
Teaching/learning strategies

ABSTRACT

A mobile guide system that integrates art appreciation instruction with augmented reality (AR) was designed as an auxiliary tool for painting appreciation, and the learning performance of three groups of visiting participants was explored: AR-guided, audio-guided, and nonguided (i.e., without carrying auxiliary devices). The participants were 135 college students, and a quasi-experimental research design was employed. Several learning performance factors of the museum visitors aided with different guided modes were evaluated, including their learning effectiveness, flow experience, the amount of time spent focusing on the paintings, behavioral patterns, and attitude of using the guide systems. The results showed that compared to the audio- and nonguided participants, the AR guide effectively enhanced visitors' learning effectiveness, promoted their flow experience, and extended the amount of time the visitors spent focusing on the paintings. In addition, the visitors' behavioral patterns were dependent upon the guided mode that they used; the visitors who were the most engaged in the gallery experience were those who were using the AR guide. Most of the visitors using the mobile AR-guide system elicited positive responses and acceptance attitudes.

1. Introduction

Augmented reality (AR) technology has been gradually applied to various fields since 1990; it can be used as a method presenting additional information using physical operation as a medium, so that users can visually see the integration of the real world and virtual images. The applications of AR currently include language studies (Liu, 2009), social sciences (Hedley, Billinghurst, Postner, May, & Kato, 2002; Mathews, 2010; McCall, Wetzel, Löschner, & Braun, 2011), mathematical sciences (Wang, 2007; Yim & Seong, 2010), natural sciences (Klopfer & Squire, 2008; Liu, Tan, & Chu, 2009), biomedicine (Strickland, Fairhurst, Lauder, Hewett, & Maddern, 2011; Vilkoniene, 2009), arts and humanities (Portalés, Lerma, & Pérez, 2009; Shen, Ong, & Nee, 2010), leisure and recreation (Portales, Viñals, & Alonso-Monasterio, 2010), and advertising and marketing (Moltenbrey, 2011). Many studies have found that AR offers visitors interesting, fun, and challenging experiences, as well as immersive sensations. With respect to its educational applications, it has been reported that both

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http://dx.doi.org/10.1016/j.compedu.2013.09.022

teachers and students feel that AR not only promotes participation and motivation, but also creates a realistic and novel learning environment via the combination of the real and the virtual (Damala, Cubaud, Bationo, Houlier, & Marchal, 2008; Dunleavy, Dede, & Mitchell, 2008; Klopfer & Squire, 2008; Mulloni, Wagner, & Schmalstieg, 2008).

However, many studies have also found that while AR with the characteristic of virtual and real coexistence appealed to users viewing the additional information within a specific field of vision, it may cause them to pay too much attention to the content (i.e., the virtual information) of the guide system and ignore the surrounding physical environment (Billinghurst, Belcher, Gupta, & Kiyokawa, 2003; Dunleavy et al., 2008; Wang & Chen, 2009); some visitors even reported that the sense of presence that was shaped by the context of the AR had disappeared and only been transitory while leaving or moving between visit locations (McCall et al., 2011).

Sung, Chang, Hou, and Chen (2010) pointed out that the planning and application of an ideal mobile guide should contain the overall learning context in the guiding environment, such as the visitors, their companions, the exhibits and their cultural and social implications. The design of the mobile guide should fully support the interaction between the visitors and these aforementioned aspects, thus forming a "human–computer–context" interaction (HCCI). In light of this, the limitation underlying the planning for mobile AR-guide activities lies in the inability to balance a visitor's attention distribution between the virtual space and the physical scenes, causing them to focus their attention on the "human–computer (guide system)" excessively, and to ignore the importance of the "human–field/situation (exhibition and local context)" in the real environment. In other words, it cannot induce the desired HCCI.

The design of a mobile AR-guide for exhibitions should therefore emphasize the coupling between the virtual space and the physical scenes (Klopfer & Squire, 2008); that is, enhance the interaction between the additional, virtual information and the real exhibits. First of all, visitors should understand the profound meaning embedded in the exhibits through observation, interpretation, and evaluation of the material objects (i.e., artwork) during guided tours. In addition, the object of appreciation should also be stressed upon presenting the original appearance of works to fulfill the demands of the public with respect to sharing and discussing the artwork, which is called "art appreciation" (Feldman, 1972, 1973; Hamblen, 1984). For example, Feldman (1972) mentioned four steps in art appreciation, that is, a brief description of the artwork, analysis of its techniques, interpretation of its meaning, and value judgments. These four steps helped guide visitors in a series of painting learning processes. It is important during the course of art appreciation to focus on each exhibit itself, facilitating visitors to take the initiative to explore the significant values of the exhibits and stimulating connections between the visitors and the exhibits. This will hopefully serve to complement the aforementioned limitations of the current AR state (Damala, Marchal, & Houlier, 2007; Dunleavy et al., 2008) and promote the "human–field/situation (exhibits)" interaction. Diverse methods of art appreciation instruction have been developed. Whether through the utilization of digital archives (Jamil, Sembok, & Abu Bakar, 2011; Lin, Cheng, & Sun, 2007; Mei, 2004) or online interactive platforms (Arends & Goldfarb, 2010; Arends, Goldfarb, Merkl, & Weingartner, 2009; Pitt, Updike, & Guthrie, 2003), integrating information technology into teaching has become mainstream; however, there has been very little research on mobile AR-guide applications.

According to Sparacino (2002), although commentary posters and text instructions occupied a lot of space at general exhibitions, most people do not spend sufficient time to read or digest the informative content. Furthermore, interactive multimedia, audio commentary playback, and other devices can be attractive, but they are not always located next to the exhibits, and can create a barrier to those exhibits, denying visitors close observation, instant comparison, and confirmation of artwork, and may even deprive their visiting time at a museum. Improvements to these restrictions have been made through studies dedicated to the applications of digital guides—such as audio or audiovisual guides, interactive multimedia kiosks, and mobile devices with radio frequency identification or the quick response code (QR Code) system on exhibition tours. However, it has also been pointed out that the use of generic digital guides (Cosley et al., 2009; Hsi, 2003; Liu, Liu, Wang, & Wang, 2009; Liu, Tan, et al., 2009; Reynolds, Walker, & Speight, 2010; Sung, Chang, et al., 2010) may cause visitors to place too much emphasis on the information in the guide device, consequently resulting in them interacting only superficially with the exhibits and reducing their focus on them. This type of visiting behavior reduces the value of the original appeal of the actual objects of appreciation, which runs counter to the pursuit of the ideal of art appreciation.

Combining the function of the mobile AR-guide with art appreciation instruction is expected to help in solving the aforementioned problems (Barber et al., 2001; Damala et al., 2007, 2008; Portalés et al., 2009). AR not only retains the advantages of the digital guide, but also allows visitors to see the supplementary explication above a painting through a camera lens, bringing the guide information and the artwork together within the user's range of vision. This method enables visitors to interpret the description provided by the AR guide by observing and comparing it with the original painting, while simultaneously reading the formal analysis and interpretation based on art appreciation instruction. They are able to think about and reflect on the exhibit observed, thus fully appreciating the form, content, and creative ideas surrounding the artwork, as well as drawing out reasonable criticism and judgment during the guide system's instructions and art appreciation. This kind of human–computer interactive process not only makes it possible to simplify the explanation of details on the painting, but also maintains the continuity of the overall viewing experience (Barber et al., 2001; Pitt et al., 2003), which promotes an in-depth understanding and reflection of the artwork.

Webster, Trevino, and Ryan (1993) believed that an interesting and exploratory human–computer experience would promote a subjective psychological state of control, attention focus, curiosity, and intrinsic interest in users (defined as "flow"), which represents the smooth, enjoyable experience accompanied by a loss of self-consciousness and self-reinforcing conditions of the human–computer interactivity (Novak, Hoffman, & Yung, 1999). The AR guide service promotes visitors' concentration and visual focus on the exhibit, and deepens the level of art appreciation and esthetic comprehension by allowing them to become more closely connected to the display entities. This helps the achievement of a certain level of flow and the coupling of the HCCI within their interaction.

Based on the current applications of AR and art appreciation, the study developed a mobile AR-guide system and applied it practically to painting appreciation activities in an art museum, by implementing art appreciation instructions. The properties of both AR technology and art appreciation theory were thus integrated to produce flow states that would allow visitors to concentrate on observing and understanding the value and meaning of the artwork within a combined real–virtual environment, and promote the learning performance with respect to painting appreciation. Besides the evaluation of learning effectiveness, the researchers also need to observe visitors' behaviors of staring, examining, and interacting with the painting in the process of painting appreciation to ensure they are attracted by the exhibits. Through the observation and video analysis of learners' visiting behaviors of using AR guide devices, the researchers can understand the time the visitors spent focusing on the paintings and their visiting behavioral patterns, which help realize if the AR system can effectively promote the interaction between the visitors and the exhibits. Meanwhile, how easy the AR system can be used and how this system can