Augmented Reality (AR)-based Learning Environments

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Augmented reality (AR)-based learning environments are argued to foster cognitive and emotional involvement. Immersion has been identified as one of the driving forces that promote learning in technology-based learning environments.

Keywords: augmented reality ; immersion ; interactive learning environments

1. Introduction

Immersive digital technologies such as augmented reality (AR) provide the user with a highly responsive and fully immersive experience of a constructed learning environment [1]. Powerful immersion involves several levels: sensory, actional, social, psychological, and symbolic [2]. The sensory level relates to visual, audio, and sensory stimuli provided by hardware. The actional level entails the perception by each student that his or her actions have an impact on the virtual environment. Immersive context with real world narratives can trigger symbolic immersion. Finally, psychological immersion is the “mental state of being completely absorbed or engaged in something” [2] (p. 3) and can happen when sensory, actional, and symbolic immersion are achieved [3]. In the educational arena, immersive environments influence attention, motivation, and academic achievement [4][5].

Despite these claims, few studies have investigated the relationship between immersion and learning outcomes in the context of AR environments that use PCs or tablets as displays rather than immersive hardware, and results so far have been conflicting [5][6][7][8]. While some studies have reported positive relations between students’ perception of immersion and learning outcomes [5][6], others did not identify this association in their results [7][8]. The subjective nature of immersion, which can be influenced by individual characteristics, may provide an explanation for the aforementioned contradictions. Researchers aim to contribute to this research topic by investigating how immersion differences might affect learning outcomes in middle school students using an AR-marker-based learning activity.

2. Immersion in Digital Environments

Immersion is considered one of the main driving forces behind student learning [5]. When highly immersed “students quickly enter a state of suspended disbelief, accept the blended real and digital environment, give their attention over to it, and engage in the variety of options available to them to access content related to the topic being addressed” [9] (p. 240).

Immersion is a subjective measure of the vividness offered by a system and the extent to which the system is capable of shutting out the outside world [10]. One of the most-used definitions of immersion is that it is “the participant’s suspension of disbelief that she or he is ‘inside’ a digitally enhanced setting” [11] (p. 66). Immersion can be understood as a technical concept to indicate “the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the senses of a human participant” [12] (p. 604) but also as a “psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences” [13] (p. 277). Immersion, seen as a technical concept, is dependent on the hardware devices and is related to notions such as interaction, control, and usability. Meanwhile, immersion understood as a psychological phenomenon can be viewed as a graduated psychological process of engagement that may foster flow and/or presence [14]. Researchers focus on the psychological process of engagement that is triggered by the students’ perception of technical aspects such as interaction, control, and usability.

Immersion is a term commonly used in games and more recently in virtual reality. However, until the pivotal study performed by E. Brown and P. Cairns (2004) [15], understanding the notion of immersion in contexts other than games was a considerable challenge. E. Brown and P. Cairns describe immersion as the process to achieve a degree of involvement with an activity mediated by technology. The process evolves through time and is controlled by several barriers that should be removed in order to achieve a deeper involvement in the activity. There are three steps to this process:

engagement, engrossment, and total immersion. To achieve the engagement level the user needs to overcome the barrier of preference and master the activity by investing time, effort, and attention. Engagement is related to the notion of cognitive absorption [16] which is defined as a state of deep involvement with software which is influenced by two important beliefs: perceived usefulness and perceived ease of use. From engagement the user may be able to become further involved with the activity and become engrossed; in this second step the user's emotions are directly affected by the activity. The involvement described at this stage mentions that the user becomes less aware of his/her surroundings and less self-aware than previously. This level stage presents some parallels with the state of flow immersion in the fact that attention is needed, sense of time is altered, and sense of self is lost [17]. From engrossment the user may be able to become further involved with the activity. Total immersion requires the highest level of attention and is related to the feeling of presence which refers to a user's subjective psychological response to a technical system [17]. It is an individual and context user response, related to the experience of "being there" [12].

3. Augmented Reality in Education

Current lower-cost and higher-fidelity Augmented Reality (AR) technological developments have led to an explosion of experimentation and development of applications such as gaming, tourism, marketing, and education. The term 'Augmented Reality' refers to the superposition of digital information over the real world, that is, added to what the user perceives naturally, creating an improved version of reality [18]. From a technological viewpoint, AR applications must fulfill the following requirements: (1) combination of real and virtual worlds, (2) real time interaction, and (3) accurate 3D registry of virtual and real objects [18]. Two families of AR applications can be identified, namely marker-based and location-based AR. The former requires specific labels to register the position of 3D objects on the real-world image and has been employed in a greater number of interventions than the latter. On the other hand, location-based AR applications use global positioning systems (GPS) to get the accurate location of physical objects. Regarding technological equipment used in AR applications, three main generations of hardware can be identified: the first generation corresponds to the use of desktop devices to interact with AR applications, the second introduces the use of mobile and tablets, and the last generation is based on the use of AR glasses. Each generation has provided a higher level of immersion than the previous one [19].

In the educational arena, augmented reality has the potential to improve not only conceptual understanding and knowledge, but also student skills, such as problem-solving, collaboration, and communication [20][21]. AR-based learning applications range from STEM education [22][23][24][25][26] to arts and humanities [27][28][29][30]. The targets cover participation going from early childhood education up to higher education and training [31][32][33][34]. The interventions have measured not only cognitive outcomes but also affective factors such as motivation [35][36], engagement [37][38], flow [39][40], presence [41][42], and immersion [43][44][45]. In general, the interventions have shown moderate to high values of affective involvement by the students, while students have shown values that range from low to moderate on variables that measure the cognitive factors. Regarding immersion, location-based AR learning environments have proved to provoke immersion and support learning due to their possibilities of building blended spaces that foster a sense of full absorption in the AR activity [46], while marker-based AR learning environments have fostered immersion when used in learning situations enhanced with activities that combine narrative situations or serious games [43][44]

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