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Teaching training in a mixed-reality integrated learning environment

Fengfeng Ke*, Sungwoong Lee, Xinhao Xu

Department of Educational Psychology and Learning Systems, College of Education, 1114 W. Call Street, Tallahassee, FL 32306-4453, Florida State University, USA

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ABSTRACT

In this mixed-method study, we examined the design and potential impact of a mixed-reality integrated learning environment (MILE) in providing the simulated and immersive teaching practice for university teaching assistants. A virtual-reality-based learning platform integrating a Kinect-enabled sensorimotor interface was developed and used by twenty three university teaching assistants. Qualitative and quantitative data on the participants' participation behaviors, engagement, and perceptions were collected via video/screen recording, interview, surveys on teaching self-efficacy and sense of presence, and eye tracking. Results indicated that the MILE reinforced sense of presence and supported the performance of an ample range of virtual teaching tasks/actions with avatar-embodied live gesturing. The environmental fidelity in the mixed-reality learning spaces, the design and arrangement of virtual agents and avatars, and the affordance of embodied gesturing and walking are salient MILE design features that affected participants' sense of presence and their virtual teaching performance.

1. Introduction

The recent development of computer hardware and software has made it feasible to incorporate Internet-based, 3D virtual reality (VR) in innovative applications of teaching, learning, and training (Abulrub, Attridge, & Williams, 2011; Gregory et al., 2013; Jou & Wang, 2013). Virtual reality (VR) or virtual world is a computer-generated 3D representation of real-life environments. A user can autonomously navigate around a VR (in the form of *avatars*) and interact with simulated objects and other avatars in real time at the same pace one would experience events in the real world (Mitchell, Parsons, & Leonard, 2007). In comparison with other computerized programs, virtual reality supports realistic, immersive simulation to enable the transfer of skills between taught and real contexts, and provides a multi-user, embodied, and interactive space for real time active learning (Cheng & Wang, 2011). It is speculated that VR can act as a promising tool for training skill application and complex problem solving that requires weighing multiple variables and situational decision making (Bertram, Moskaliuk, & Cress, 2015; Cheng & Wang, 2011; Dede, 2005, 2009).

The emerging 3D body sensory technology, such as Microsoft Kinect, can be used as an intuitive interface to create a naturalistic, augmented interaction between users and a VR-based simulation, thus merging real and virtual worlds to support the mixed reality (Ohta & Tamura, 2014). A Kinect captures a user's body gestures and replicates them in a computer application, which offers new ways of human-computer interaction in educational settings. In a Kinect-enabled, mixed-reality environment, a user can use physical body movements to interact with the virtual characters and objects in the virtual reality. Kinect-based applications in a VR setting may help to enhance the sense of presence and immersion, and facilitate embodied and situated cognition of learners.

The use of a mixed-reality integrated learning environment (MILE) is just emerging (Hayes, Straub, Dieker, Hughes, & Hynes, 2013; Liarokapis & Anderson, 2010; Staub, Dieker, Hynes, & Hughes, 2014), and is in need of empirical research on its design, implementation, and educational effectiveness. In this study, we examined the design and application of a mixed-reality integrated learning environment – a virtual reality learning platform that integrates a Kinect-enabled sensorimotor interface – in the setting of teaching training for university teaching assistants. Teaching is a complex problem solving task that requires contextualized and adaptive implementation of content representation and (both verbal and embodied) interpersonal interaction. Learning to teach is a challenging and important area of inquiry for educational

* Corresponding author. Department of Educational Psychology and Learning Systems, College of Education, 3205-C Stone Building, Tallahassee, FL 32306-4453, The Florida State University, USA.

E-mail addresses: fke@fsu.edu (F. Ke), sl09d@my.fsu.edu (S. Lee), xx11@fsu.edu (X. Xu).

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practice and research (Quintana & Fernández, 2015). Examining the implementation of MILE for teaching training will help to inform the role of this emerging platform in providing embodied, immersive interactions for learning a complex task, and to test its implementation feasibility via the lens of future teachers. Specifically, this exploratory study aimed to address two research questions: (1) What is the effectiveness of the mixed-reality integrated learning environment for teaching training? (2) What features of this learning environment influence participants' perceptions and teaching-training experiences?

2. Theoretical framework

2.1. Sense of presence and immersion in a virtual learning environment

Sense of presence refers to "a state of consciousness" and the psychological sense of being in the virtual place (Barfield & Hendrix, 1995; Heeter, 1992; Lee, 2004; Slater & Wilbur, 1997, p. 1; Witmer, Jerome, & Singer, 2005). Previous studies reported that sense of presence reduces the social distance between learners, and enhances skills acquisition and knowledge transfer by allowing multiple perspectives and situated performance (Dede, 2009; Mantovani & Castelnuovo, 2003; Palloff & Pratt, 1999; Slater & Wilbur, 1997). It was found that sense of presence in virtual learning environments foster learners' motivation, learning engagement, and potentially learning outcomes, by enabling focused and naturalistic interactions with learning materials and activities (Mikropoulos, 2006; Persky et al., 2009; Selverian & Hwang, 2003).

A design construct closely related to sense of presence is immersion – the extent of "the subjective impression that one is participating in a comprehensive, realistic experience" and "the semi-voluntary experience of being transported into an alternate context for an extended duration" (Buchanan, 2006, p. 10; Dede, 2005, p. 10). Prior research suggested that the higher level of immersion is associated with the higher level of presence (Bystrom, Barfield, & Hendrix, 1999; Faiola, Newlon, Pfaff, & Smyslova, 2013; Slater & Wilbur, 1997). Experience of immersion can be created via the sensory and environmental fidelity in the three-dimensional virtual space, engagement with the virtual actions, and emotional experience activated by the archetypical scenarios in the virtual space (Dede, 2009).

The recent development of computer hardware and software has made it feasible to incorporate Internet-based, 3D virtual reality (VR) to create an immersive learning environment (Abulrub et al., 2011; Gregory et al., 2013). In fact, VR has been implemented as a promising learning platform to support a variety of education activities in both formal and informal learning settings (Hew & Cheung, 2010; Jou & Wang, 2013). In a qualitative, observatory study, Quintana and Fernández (2015) reported that immersive virtual reality can provide a virtual space to simulate teaching challenges and hence act as a pedagogical tool for the collaborative teaching training program. In comparison with other computerized programs, VR is characterized with representational fidelity and learner interaction, supports a psychological sense of presence and an immersive practice to facilitate experiential learning, and provides a multi-user space for embodied interactions (Dalgarno & Lee, 2010). Previous studies suggested that the immersive VR learning environment also fosters situated learning through simulating authentic contexts and providing contextualized learning activities (Bailenson et al., 2008; Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007; Ketelhut, Dede, Clarke, Nelson, & Bowman, 2007), thus improving performance transfer from the learning context to the real-world setting (Bossard, Kermarrec, Buche, & Tisseau, 2008; Park et al., 2007). The unique affordances of an immersive VR learning environment include: (a) virtual agents and avatars that act as personalized and interactive learning partners that cannot be easily arranged in a physical setting, (b) the open-endedness in creating and customizing the 3D VR environment that enables the provision of multiple perspectives and scenarios for the targeted concepts and skills, and (c) the potential to transform sensory representations to enhance virtual learning actions (Bailenson et al., 2008; Dede, 2009).

2.2. Embodied and situated cognition

Situated and embodied cognition theories hold that cognition is not abstract or centralized but a situated activity that takes place in active and continuous interactions with the environment, vastly via perceptual and motor activities (Brown, Collins, & Duguid, 1989). Motor functions are traditionally considered only peripheral input and output devices for the 'central' cognitive processes. But the evolving perspective of embodied cognition argues that cognitive processes are deeply rooted and should be understood in the context of the body's interactions with the environment (Anderson, 2003; Shapiro, 2010; Wilson, 2002). Sensorimotor processing, thus, becomes a meaningful context and a necessary part of cognitive processing. Another perspective of embodied and situated cognition is that cognitive processing can be off-loaded onto the external environment, via either real-time, task-relevant actions or off-line, mental simulations of sensorimotor experiences. The emergence and development of 3D motion sensing technology, such as Microsoft Kinect, has provided a valuable and exciting avenue for implementing and examining the propositions of the embodied and situated cognition when designing an active and meaningful learning environment.

Schubert, Friedmann, and Regenbrecht (1999) framed presence as the consequence of embodied cognition – presence emerges when bodily actions in a virtual environment are mentally represented and the virtual environment is actively interpreted. The central interactions with the virtual environment that foster embodied presence are the representation of navigation and movement of one's own body as an action in the virtual world (Bailenson et al., 2008; Schubert et al., 1999). Prior research on learning in virtual learning environment typically examined embodied agents (driven by computer algorithms) as opposed to avatars (driven by humans in real time). It is due to the lack of readily available commercial technology that allows the creation of digital avatars who track and render users' gestures in a collaborative virtual learning environment (Bailenson et al., 2008). Hence it is necessary to conduct an empirical investigation to explore the implications of the behavioral realism (i.e., embodied presence) of the avatar enabled by the body sensory technologies in the VR environment for learners' sense of presence and engagement.

2.3. Mixed-reality integrated teaching training for graduate teaching assistants

Teaching is a complex problem-solving task that requires weighing many variables and adaptively implementing principles of instruction, communication, and content representation in a highly situated context (Dick, Carey, & Carey, 2011). Rather than mechanically executing a preset sequence of instructional events, teaching involves dynamic and complex interpersonal interaction skills. Graduate teaching assistants (GTAs) participate extensively in class, laboratory, and recitation teaching in higher education. Teaching training for GTAs, then, is critical for supporting curriculum reforms, bolstering college teaching and learning, and training future faculty members (Marincovich, Prostko, & Stout, 1998; Park,