Perspective Taking in Participatory Simulation-based Collaborative Learning

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Abstract: This experimental study examined participatory simulation-based collaborative learning in a teaching training setting. A virtual-reality (VR) supported, embodiment integrated learning system is constructed to enable collaborative and contextualized teaching practices by university teaching assistants. A total of 40 teaching assistants participated in a 4-hour teaching training session, during which they were randomly assigned to a VR-supported and a live simulation group. Participants reported significantly higher teaching self-efficacy after the training. The VR participatory simulation better promoted the post-session, lab-teaching knowledge test performance than the live simulation. 'Bicentric' perspective taking embedded in VR-based interactions facilitated both experiential and vicarious learning. Yet a concurrent hybrid presence framed by the virtual and physical collocation of participants exerted an over-reliance on individual autonomy in VR simulation-based collaborative learning.

Introduction and literature review

Simulation refers to the imitation or representation of dynamic features and structural elements of a real-world system, entity, phenomenon, or process (Frasson & Blanchard, 2012). A *participatory simulation* extends and integrates a real-world representation with participatory and collaborative role-play—'diving into' the simulated space and directly engaging with the simulated system or phenomenon (Colella, 2000; Ackermann, 2012).

According to Piaget (2005) and Ackermann (2012), both perspectives of "diving in" and "stepping out" are important for deeper understanding. By "diving into" a variety of situations and becoming part of the phenomenon, the learners are connected and sensitive to variations in the environment in reacting to their actions. By "stepping out" of the situations or momentary withdrawal from immersion in the experience, the learner then gets the chance to *reflect on* their experience from a distance to form more abstract, symbolic insights and achieve "reflexive abstraction." Through shifting between "diving-in" (egocentric) and "stepping-out" (exocentric) perspectives, learners are able to differentiate and coordinate different viewpoints to discover foundational rules governing the phenomenon (Ackermann, 2012; Dede, 2009).

Although such an integrative, "bicentric" frame of reference is argued to support the mastery of complex, multidimensional information (Dede, 2009), the design and research of a bicentric perspective in simulation-based collaborative learning is lacking. Prior research of participatory simulations predominantly studied the single "diving in," immersive experience, focusing on a simulation with surrounding projection or a pervasive play experience. To extend prior research, this current examination is aimed to explore the design and learning effectiveness of a participatory simulation that: (a) integrates both perspectives in its interactivity, and (b) enables the shifting between immersive role-playing and "stepping-out" observation of the simulated phenomenon by blending a virtual and a physical learning space.

Virtual reality for participatory simulation with a bicentric perspective

The nature of virtual reality is defined as "Immersion-Interaction-Imagination" by Burdea and Coiffet (2003). Virtual reality (VR) enables and integrates a 3D immersive user interface, multimodal and real-time interactivity, participatory narrative, and persona construction that promotes imagination creativity. VR also allows the user to view and interact with a virtual object, space, or phenomenon from egocentric and exocentric perspectives. These salient features of VR make it a promising platform of collaborative, participatory simulation with dynamic perspective taking. A recent meta-analysis of the effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education indicated that virtual worlds were effective in improving learning outcome gains (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014).

Although isolation from the physical environment is considered immersive, it is not a prerequisite for the situated immersion (Witmer & Singer, 1998). It is argued that one's immersion in a virtual space does not require the total displacement of attention from the physical locale, because typically attention is divided between the physical world and the mental world of imaginations, memories, and other cognitive activities. In other words, individuals experiencing a virtual space can concurrently attend to aspects of the virtual space and events in their physical environment.

Simulation-based teaching training

Teaching is complex problem solving that requires contextualized information representation and multimodal interpersonal interactions. Cruickshank (1986) summarized four levels of strategies in teaching training: (a) concrete-real – infield and clinical experiences of student teaching; (b) concrete-modeled – simulated teaching experiences, such as role-playing, microteaching, and simulation; (c) vicarious – observations of others teaching live in classrooms or on tape, and (d) abstract – learning from lectures, case studies and discussions. Teaching training in university has traditionally relied on abstract instructional strategies. The need for training to bridge the gap between abstract and concrete-real experiences of teaching is critical for future university instructors (DeChenne et al., 2012).

The use of virtual reality to promote simulation-based teaching training is just emerging (Ke, Lee, & Xu, 2016). In a recent qualitative, observatory study, Quintana and Fernández, (2015) reported that VR can provide a virtual space to simulate teaching challenges and hence act as a pedagogical tool for the collaborative teaching training program. Gregory and Masters (2012) conducted a study on using SecondLife-supported VR for pre-service teachers to practice teaching. The study reported that VR-based simulation and role-playing made pre-service teachers "think in complex and creative ways by assisting them in considering multiple perspectives on a topic" (p.427). Gregory and Masters (2012) called for future research on designing VR training to serve as a complementary part for teachers with both real-life and virtual accesses.

Methods

By investigating a VR-supported, participatory simulation in comparison with the live simulation in the collaborative learning setting, this study aimed to address the following research questions: *To what extent will the VR-supported participatory simulation, compared with the live simulation, support teaching practices and knowledge development*? An experimental, pretest-posttest control group design was adopted. Both quantitative and qualitative data on participatory simulation-based collaborative learning were collected.

Participants

Forty university teaching assistants were recruited from the chemistry department in a land-grant university in United States. These participants included 22.5% females and 77.5% males, with 50% of them not having teaching experience and 37.5% being non-native English speakers. Twenty one participants were randomly assigned to the VR-supported simulation group while the other 19 were assigned to the live simulation group. Both groups participated in a 4-hour, synchronous training session in a physically co-located setting, with the VR simulation group staying in a computer lab and the living simulation group being in a chemistry classroom.

Simulation-based collaborative learning environments

VR-supported participatory simulation

In the VR simulation-based learning setting, participants were physically seated in the computer lab and participated in collaborative role-play through a 3D, VR-supported simulation. Using OpenSimulator, a virtual campus was designed to simulate daily teaching scenarios, such as *lab teaching, recitation*, and *assignment tutoring.* Participants were assigned into two sub-groups. Within each sub-group, participants shifted the roles of instructor and student in the teaching scenarios, following a semi-structured protocol that outlines the backdrop mission, structure, and planned procedure of the collaborative roleplay. Each participant was provided a randomly-assigned, role-play notecard describing a specific learner or instructor profile with exemplary scripts. Every participant wore headsets during the training session, and there were dividers in between their seats. They did reflective group debriefing via VR voice and text chats at the end of each teaching simulation.

Using Microsoft Kinect and a middleware that interfaced Kinect with the OpenSimulator platform, the VR-based teaching simulation enabled participants to project and embody real-time body movements and gestures onto their avatars in the virtual world. Specifically, it enabled embodied gesturing in virtual lecturing.

Implementing VR-supported simulation in a physical co-located space would create a hybrid space that allows trainees to engage in collaborative role-play in a virtual space through virtual avatar embodiment, while maintaining a real-world identity to do reflective and vicarious (or observational) learning of their virtual-world performance. VR simulation also supports the sifting between the first and third person points of view during the interaction and navigation. W*e hypothesized that* the hybrid, virtual-physical learning space as well as the bi-centric interaction interface of the VR simulation would offer trainees a dynamic “diving-in” and “stepping-out” perspective taking during participatory simulation-based learning.

Live participatory simulation

In the live simulation-based learning setting, participants were physically seated in a typical chemistry classroom. Facilitated by an experienced teacher trainer, they performed collaborative role-play—acting and shifting being the instructor or student in simulated teaching scenarios. The structure and protocol of simulation-based collaborative learning activities in the live simulation setting were similar to those in the VR simulation group, except that all activities were performed face to face in a physical space—an actual classroom.

Data collection

All Participants received a teaching knowledge test and a teaching self-efficacy survey before and after the study session. The teaching knowledge test was developed based on the existing graduate teaching training materials of the chemistry department, and encompassed 12 lab-teaching story problems (Cronbach’s α=.88 in this study) and 4 recitation/tutoring story problems (Cronbach’s α=.61). Each problem presented a scenario narrative and asked participants to select all applicable problem solutions in a checklist. Each item is scored on the number of correct answers selected. The STEM Graduate Teaching Assistant (GTA) teaching self-efficacy survey by DeChenne, Enochs, and Needham (2012), validated in prior research on GTA teaching training, was adopted in the study. The survey consists of 15 five-point Likert scale items (Cronbach’s α=.95 in this study).

Participants’ learning interactions in the two simulation-based learning settings are observed, screen captured, and voice recorded. A semi-structured group interview was conducted at the end of the study session, focusing on exploring participants’ perceptions of their learning experiences.

Data analyses

We conducted descriptive statistics and pairwise t-tests with the pre- and posttest results to examine the potential changes in participants’ teaching knowledge and self-efficacy before and after the study session. We then did ANCOVA analyses to investigate whether there was a difference between the two modes of participatory simulation in supporting participants’ teaching knowledge and self-efficacy development. We also performed a qualitative thematic analysis with the qualitative data to examine salient themes that depict the attributes and the nature of simulation-based collaborative learning in the two simulation settings. The qualitative findings provided descriptive evidence and explanation on the features of the two participatory simulation environments and their impacts on participants’ collaborative learning processes.

Findings

Modes of participatory simulation on teaching knowledge

A one-way ANCOVA was conducted to compare the effect of simulation modes on the post-session lab-teaching scores of participants in the VR and live simulation conditions, with the participants’ pre-session scores as the co-variate. There was a borderline significant effect of the simulation modes on the lab teaching scores, $F(1, 33)= 3.48$, p=.07, partial η^2=.10. The VR-supported participatory simulation group (M_v=28.80 out of 43, SE_v=5.38, n=20) scored higher than the live participatory simulation group (M_l=24.63, SE_l=6.14, n=16).

The ANCOVA on the effect of simulation modes on the post-session recitation/tutoring scores of participants in VR and live simulation conditions also indicated a significant result, $F(1, 37)= 23.54$, p<.001, partial η^2=.39. Differently, the live participatory simulation group (M_l=7.47 out of 17, SE_l=1.65, n=19) scored higher than the VR-supported participatory simulation group (M_v=5.81, SE_v=2.20, n=21) in the post-session recitation/tutoring knowledge test.

Modes of participatory simulation on teaching self-efficacy

A one-way ANCOVA was conducted to compare the effect of simulation modes on the post-session teaching self-efficacy scores of participants in VR and live simulation conditions, with the participants’ pre-session scores as the co-variate. There was not a significant effect of the simulation modes on the teaching self-efficacy scores, $F(1, 34)= 0.15$, p=.71. The pairwise t-test comparing the teaching self-efficacy of all participants (n=37) before and after the training session indicated a significant result, $t(36)$=-2.76, p<.01, d=-.31. Participants scored higher in the teaching self-efficacy responses after the session, M_{pre}=63.24 out of a total of 75, SD_{pre}=7.73; M_{post}=65.03, SD_{post}=8.21.

Qualitative findings

Two salient themes governing the features of VR-supported participatory simulation in relation to collaborative learning processes and outcomes emerged from the qualitative data: (a) experiential and vicarious learning enabled by a bicentric interaction interface, and (b) inconsistency and heterogeneity in resource or effort allocation across the hybrid learning spaces. We observed that more than 50% of the role-playing or learning interactions in the VR-based simulation involved participants' shifting points of view; the frequency of enacting ego- and exocentric perspective alternation during the interactions tended to be positively associated with both prior teaching experience and the post-session teaching knowledge performance. An interpretation is that dynamic perspective taking embedded in the VR interactions facilitated both "diving-in" experience and evaluative observation of each other's teaching practices.

On the other hand, a concurrent hybrid presence framed by the virtual and physical collocation of participants in the VR simulation was associated with a reliance on individual autonomy in coordinating one's simulated and real-world personae during collaborative role-playing. As a result, participants showed differing level or pacing in allocating their attentional resources in between VR-based collaborative role-playing and "stepping-out" reflection/observation. Their attention allocation to the collaborative role-playing also fluctuated based on the contextual demand, with the "diving-in" input obviously reduced in teaching scenarios that prioritize lecturing or concept explanation (e.g., recitation/tutoring). The inconsistent and inequivalent individual learner involvement in collaborative role-play created frustration and may have moderated the experience of immersion and interactivity in VR simulation-based learning. In comparison, the live simulation participants demonstrated a similar and consistent level of engagement in collaborative role-playing.

Implications and significance

The study findings generally support the feasibility and effectiveness of a VR-supported participatory simulation that enables dynamic perspective taking in the collaborative learning of a complex task. The study indicates an interaction between the design of perspective taking and learner autonomy in collaborative role-play. It will help to inform not only the approach of concrete, modeled teaching training in an accessible manner, but also design strategies in relation to perspective taking, interactivity, and immersion that enhance simulation-based collaborative learning.

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