E Online Presence

E.1   Do learners experience spatial and social presence in interactive environments based on 360-degree panoramas? A pilot study and future research agenda

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1   Introduction

The unforeseeable outbreak and progression of the covid-19-pandemic accompanied by crucial measures of both social and spatial distancing has emphasized digital technologies' role within the spotlight of educational research and practice. A major challenge of technology-enhanced education is the preservation of the spatio-social character of learning despite distance. Virtual learning spaces hold the potential to spatially situate learning and make learners feel like actually being in a real physical learning environment (e. g., Hartmann & Bannert, 2022; Eiris et al., 2020, Makransky & Mayer, 2022). Compared to highly immersive virtual realities that are, for instance, accessed through a head-mounted display, interactive virtual learning environments based on 360-degree panoramas are less expensive to produce while seeming to enable comparable experiences of presence (Eiris et al., 2020; Ritter & Chambers, 2021). However, this rather novel learning format has not yet been empirically investigated in depth, neither in terms of its foundation nor regarding learners' experience of presence during its use. The subsequently described study aims to provide a first in-depth insight into learners' spatial and social presence experience in interactive 360-degree panoramas. Therefore, we first summarize the current theoretical and empirical state of research. We then present the methodological approach and results of the study conducted, discuss them critically, and derive a comprehensive agenda for follow-up research.

1.1   Towards a definition of 360-degree panorama-based interactive virtual learning environments

V*irtual environments* are computer-generated displays that enable or compel users "to have a sense of being present in an environment other than the one they are [physically] in, and to interact with that environment" (Schroeder, 1996, p. 25). When designed as informational/social spaces to enrich classroom activities or enable distance learning, virtual spaces can be referred to as *virtual learning environments* (Dillenbourg et al., 2002).

While three-dimensionally modeled environments have become a subject of growing importance within educational research during the recent years and are increasingly applied in educational practice, virtual spaces based on 360-degree panoramas represent a rather novel and rarely researched form of a virtual learning environment. The 360-degree panoramas, which serve as visual-technical basis, are referred to as "omnidirectional views of the complete environment encircling the observer, creating a virtual space that replicates the viewpoints surrounding a user" (Eiris et al., 2021, p.3). Unlike dynamic 360-degree based media, such as 3D modeled mixed or virtual realities respectively 360-degree videos which comprise continuous sequences of images that users automatically or manually navigate through, 360-degree panoramas are merely static camera shots depicting a single scene. While the use of such techniques is widely established in real estate industry to enable property inspections over distance, their application for educational purposes is a trend that just emerged during the recent years. When designed to promote knowledge and competence acquisition and enriched with elements that users can interact with, for instance virtual agents or clickable/touchable hotspots, we understand 360-degree-panorama based virtual spaces as *360-degree-panorama based interactive virtual learning environments*. To create such an environment, a physically existing construction site may, for example, be photographed using a 360-degree camera and converted into a 360-degree environment with the help of suitable software. Subsequently, it is enriched/extended with digital elements that are not present in the physical template, like context-specific hazards. Because of their spatial-situational nature, the thereby created virtual learning environments are particularly suitable for the acquisition of competencies related to actions that require spatial abilities (e. g., Eiris et al., 2021). For instance, they may serve trainees or professionals as a safety training to identify more or less common hazards on a construction site and learn to consider them appropriately.

1.2 Benefits of 360 panorama based interactive virtual learning environments

The upcoming trend of using 360-degree panorama based virtual spaces in education is predominantly driven by current research. According to a series of pilot studies, students who trained safety hazard identification by the use of a 360- panorama-based learning environment achieved similar outcomes to another group who physically visited the construction sites (Pham et al., 2018a; Pham et al., 2018b). According to a further study, a group of learners who used a learning space based on a 360 panorama performed equal to another group who underwent a paper-based intervention to gain abstract knowledge about the use of construction materials (Eiris et al., 2021). Furthermore, subjects in the 360-degree panorama condition even outperformed paper-based learners in two problem-solving tasks that required direct observation of site material properties and their spatial relationships (Eiris et al., 2021).

While another pilot study that compared an interactive 360-degree panorama to a 3D modeled virtual reality (VR) condition (Moore et al., 2019) revealed slightly higher descriptive learning results for subjects which learned with the latter, a further experimental comparison on learning about photovoltaic plants shows better testing results for the 360 panorama based group compared to participants of the 3D modeled condition (Ritter & Chambers, 2021). When considered in the light of the – compared to the development of complex 3D modeled virtual realities – significantly lower effort and costs that are required to create panorama based interactive learning environments by the use of simple reality-capturing techniques (Eiris et al., 2021; Wolf et al., 2021), 360 panorama based learning applications in sum appear a superior alternative to enable spatially-situated information processing (see Hartmann & Bannert, 2022) with regard to their cost-benefit ratio.

1.3 Learners' experience of presence in 360 panorama interactive virtual learning environments

While previous studies have predominantly focused on learners' performance achieved by the use of 360-degree-based educational spaces, there has been limited research on the rationale for the conduciveness of such environments to learning. One may argue that their potential for teaching and learning originates from their ability to offer a unique sense of presence (Reyna, 2018). *Presence* can be considered "the subjective experience of being in one place or environment, even when one is physically situated in another" (Witmer & Singer, 1998), resulting in "a psychological state in which the virtuality of experience is unnoticed" (Lee, 2004, p. 32). By reviewing numerous approaches and definitions, Lombard and Ditton (1997) identified six conceptualizations of presence: Transportation, realism, immersion, social richness, social actor within a medium, and medium as social actor. To gain a first sophisticated glimpse into the experience of presence during learning with 360-degree panorama based interactive environments, we however focus on two dimensions that have most extensively studied during the last years: Spatial and social presence. *Spatial presence* refers to the perception of self-location in an environment conveyed by some kind of media technology "in which virtual (para-authentic or artificial) physical objects are experienced as actual physical objects in either sensory or nonsensory ways" (Lee, 2004, p.44) while *social presence* can be defined as "a psychological state in which virtual (para-authentic or artificial) social actors are experienced as actual social actors in either sensory or nonsensory ways" (Lee, 2004, p. 45) that may evoke parasocial interaction with such actors. To date, two pilot studies have been conducted to investigate whether a sense of presence arises when learners encounter 360-degree panorama-based spaces. According to the first study, there was no significant difference in presence reported by students who learned with a 360 panorama interactive environment and another group that used a 3D modeled VR space (Ritter & Chambers, 2021).

A similar comparison found equal results for professionals, while students in the 360-degree condition reported even higher feelings of presence than their counterparts using 3D VR (Eiris et al., 2020). These findings lead to the conclusion that 360-degree panorama based virtual spaces are capable of evoking a (notable) sense of presence in learners. However, both studies used condensed presence questionnaires which do not assess specific dimensions of presence, namely the Presence Questionnaire (PQ; Witmer & Singer, 1998) and the Slater-Usoh-Steed (SUS) presence questionnaire (Slater et al., 1994). Consequently, the objective of the present work is to gain more sophisticated insights into individuals' experience of presence while using 360-degree-panorama-based interactive environments for learning purposes. By means of a case study, we aim to answer the research question whether and to what extent learners experience spatial and social presence in an example interactive 360-degree panorama.

2   Method

2.1   Participants

In total, 44 real estate agents undergoing an apprenticeship or continuing education (56.8% female; age: $M = 22.00$ years, $SD = 5.89$) participated voluntarily in the study. Among the subjects, eleven persons (25.0%) held a secondary school diploma, while 28 persons (63.6%) graduated with a high school degree, and six persons (11.4%) had successfully completed vocational training. Participants assessed their prior experience with 360-degree technologies for general ($M = 1.93$ out of 5; $SD = 0.04$) or learning purposes ($M = 1.18$ out of 5; $SD = 0.39$) as (rather respectively very) low. In contrast, they reported a medium to high technology commitment ($M = 3.81$ out of 5; $SD = 0.57$).

2.2   Materials

A virtual learning space served as the material to assist current or future real estate professionals in updating and expanding technical legal knowledge on conducting owners' meetings. It is visually based on four 360-degree panoramic shots of a classroom in the education provider's facility, taken with an Insta360 Pro camera. For the scene, a hybrid owners' meeting was recreated, with one person in the role of the property manager and several mock apartment owners sitting at a table formation beside a digital whiteboard, where various documents (such as binders) and digital devices (such as tablets) have been placed. Furthermore, a lecturer and a pedagogical assistant are displayed within the room. The 360-degree panorama was augmented with further elements (e. g., an advance organizer) and interactive hotspots by use of the authoring tool 3DVista. For instance, the hotspots lead to a textual introduction, a prior knowledge self-assessment, four learning videos as hidden objects that learners must discover, a final quiz, and a take-home message. Learners may navigate the room by selecting the directional arrows depicted on the floor.

A section of the 360 panorama-based interactive virtual learning environments is shown in Figure 1. For a more detailed description of the didactic concept and technical implementation of the learning space, see Dyrna, Stöhr, Zawdizki, & Filz, 2021.

Figure 1: Sample section of the created learning space for real estate training

2.3 Measures

Pre-questionnaire. Participants' *age*, *perceived gender*, and *qualification* were assessed by the use of three ad-hoc questions with suitable items (e. g., "Which gender do you feel yourself to belong to?" offering the options "female", "male", and "diverse"). Subjects' general and learning related *prior experience with 360-degree technologies* were measured by the use of two ad-hoc questions (e. g., "How often did you already use 360-degree technology?"), each to be rated on 5-point Likert scales (ranging from "very rarely" to "very often"). To assess the participants' *technology commitment*, we used the Technology Commitment Short Scales (Neyer et al., 2012). It encompassed four items (e. g., "I quickly enjoy new technical developments.") for each of the three subscales to assess the dimensions of technology acceptance ($\alpha = .80$), technology literacy beliefs ($\alpha = .74$), and technology control beliefs ($\alpha = .67$) to be rated on a 5-point Likert scale (ranging from "Does not apply at all." to "Does fully apply.").

Post-questionnaire. To measure learners' *spatial* and *social experience* of presence within the virtual learning space, we used the corresponding scales for spatial presence (7 items; $\alpha = .66$; e. g., "To what extent did you experience a sense of being there inside the environment you saw/heard?") and social presence of the Temple Presence Inventory (TPI; Lombard et al., 2009).

The social presence scales encompassed three subscales to measure learners' *active interpersonal social presence* (3 items; α = .75; e. g., "How often did you (want to) speak to a person you saw/heard in the media environment?") and *passive interpersonal social presence* (4 items; α = .74; e. g., "How well were you able to observe the facial expressions of the people you saw/heard during the media experience?") as well as their *parasocial interaction* (7 Items; α = .93; e. g., "To what extent did you feel you could interact with the person/people you saw/heard?") with the displayed individuals. All presence scales were to be assessed on 5-point Likert scales ranging from "not at all" to "very much".

2.4   Procedure

We enrolled the present study as a field test in curricular classroom lessons of three real estate agents' courses, two respectively of apprentices and one of professionals undergoing continuing education, taking a duration of 90 minutes each. The responsible teachers were present in the classroom to ensure accustomed circumstances. After receiving standardized instruction from the investigators, the participants were to answer the pre-questionnaire (provided in a pen-and-paper format). Subsequently, the subjects processed the 360-degree-panorama-based interactive virtual learning space using standard notebooks (1920x1080px screen resolution) provided by the education provider located in Saxony (Germany). Finally, participants had to complete the final pen-and-paper post-questionnaire described above.

3   Results

We performed descriptive statistical analyses using SPSS 23 to gain insights on learners' extent of feeling spatially and socially present in the 360-degree-panorama-based interactive space. According to the results, subjects assessed both perceived spatial ($M = 2.24$; $SD = 0.67$) and social presence ($M = 2.78$; $SD = 0.74$) as rather low to medium. Averages for spatial presence ranged from 1.00 to 3.71, while reported social presence ranged from 1.33 to 4.29 on average. In terms of the subdimensions, the participants assessed their perceived active interpersonal social presence ($M = 2.31$; $SD = 0.96$; $1.00 \leq Ms = 4.33$) and parasocial interaction ($M = 2.23$; $SD = 0.98$; $1.00 \leq Ms = 4.29$) as rather low to medium. In contrast, the subjects reported a medium to rather high passive interpersonal social presence ($M = 3.78$; $SD = 0.79$; $2.00 \leq Ms = 5.00$). All results are displayed in Figure 2.
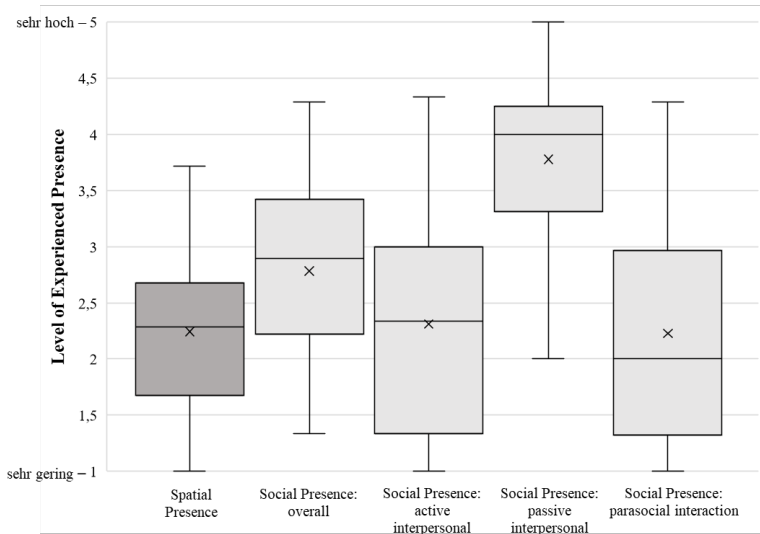
Figure 2: Learner's experience of presence within the virtual learning space

4   Discussion and future research agenda

First, the present study was able to replicate the findings by Eiris et al. (2020) and Ritter & Chambers (2021), underlining the capability of 360-degree-panorama-based interactive virtual learning environments to evoke feelings of presence among learners. In addition, we showed that their presence experience can be both spatial and socially. The discovered variance between the overall perceived presence with regard to its dimensions and subdimensions, and in the individual differences among subjects within each dimension or subdimension, may be attributable to the specific design of the 360 panorama interactive space and to learners' personal states and traits. These aspects address certain limitations of the conducted study and lead to an agenda for future research on 360-degree-panorama-based learning environments that comprises three major areas:

(1) *The exploration of design principles to evoke (specific types of) presence in 360-degree-panorama-based interactive learning spaces.* In line with previous research on VR (Cummings & Bailenson, 2016), learners' presence experience may increase with higher degrees of freedom in their tracking, for instance embodied by the number of points they can navigate to (which the piloted space contains only four of).

With regard to the significantly lower reported active interpersonal social presence compared to their passive counterpart, perceived social presence may be strengthened when the displayed social entities show a more realistic behavior and higher user interaction (for an overview see Oh et al., 2018). Consequently, the subjects' rather low active interpersonal social presence experience may be explained by the static presentations of social entities (i. e., persons) that represent a limitation of the piloted environment. Animated agents that provide verbal or non-verbal feedback to learners may, in contrast, strengthen their feelings of social presence.

(2) *The investigation of individual differences that influence the perception of presence in such learning environments.* With regard to previous research (for an overview see Oh et al., 2018), we for example assume that females and or persons with a higher transportability (e. g., Kim et al., 2013) are more likely to experience stronger social presence while using 360-degree-panorama-based interactive virtual learning environments. Such factors, that have not been considered during the conduction of the present study, are likely to explain the partially very high variances that the subjects in our pilot study experienced with regard to their feelings of presence across all assessed dimensions and subdimensions.

(3) *Research on the relationship between evoked feelings of presence and learning outcomes in 360-degree-panorama-based education.* The primary goal in designing a learning environment of any kind must be to make it as conducive as possible to the learning process and performance. Consequently, and in contrast to the present study that elided this relation the quality and quantity to which eliciting presence affects learning in 360-degree-panorama-based spaces needs to be examined. Some studies on immersive VR exposed detrimental effects of perceived presence on learning (e. g., Makransky et al., 2019). In line with their results, a comparative examination of 360-degree panorama and 3D VR-based environments to acquire hazard-identification skills found an inverse correlation between subjects' presence scores and learning outcomes (Eiris et al., 2020). In contrast, a current meta-analysis revealed a positive relationship between learners' feelings of social presence and perceived outcomes (Richardson et al., 2017). As a result, careful consideration and sound research must be undertaken to ensure that a higher level of presence does not distract learners in 360-degree-panorama-based interactive environments, but rather strengthens their focus on essentials. We would like to encourage researchers to take up and expand our proposed research agenda, ideally by examining a broader sample that contains more domains of learning than the study conducted, to explore this promising innovative learning format in more depth.

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