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Investigating Students' Immersion in Relation to Cultural Heritage Learning in a Virtual Reality Environment

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Abstract: This case study analyzed an IVR activity to understand (a) whether immersion reflects a subjective psychological process towards presence and flow or whether these states reflect objective properties of VR, as well as (b) the relation of immersion to learning. Data were collected with questionnaires, post-VR-activity interviews, and screen-recordings of the activity of two higher education students. Our findings supported a subjective nature of immersion as well as a positive relation to students' learning.

Introduction and theoretical framework

Recently, there is an increasing interest in using Immersive Virtual Reality (IVR) in K-16 education. However, empirical studies have often resulted in contradictory findings when comparing the learning effectiveness of IVR to traditional instruction with low-immersion media (Hamilton, 2021). One main explanation provided so far, is that IVR environments may induce a sense of presence and flow but that they may also detract students from the learning process. We argue that this explanation is not sufficient, and that presence and flow is not a given in IVR, as immersion is an individual and subjective psychological process. Similarly, Agrawal et al. (2020) note an ongoing debate on whether immersion reflects a subjective psychological process or whether it is simply an objective concept reflecting the technical affordances of VR. This work examines this issue by focusing on two higher education students, who participated in a case study structured around an IVR for cultural heritage learning to ask: (a) What was the nature of experienced immersion for each student?, (b) What were the main factors affecting the students' experienced immersion?, and (c) What was the relation between immersion and learning?

Methodology

Learning intervention

An IVR learning environment was designed to support learning about a cultural heritage site (an early Christian Byzantine church), dated to 5th century A.D. in Cyprus. The IVR environment employs an inquiry-based learning scenario according to which students assume the role of historians who investigate the dating of a church ceiling mosaic through the collection of evidence.

Participants

As a case study approach, we recruited two higher education students who were communication studies juniors at a public university. Susan was 21 years-old while Tom was 23 years-old (both names are pseudonyms). Both students voluntarily participated in this case study. The students had no prior experience with VR environments.

Data collection and analysis

Screen-recording of the VR learning experience: Each student used a head mounted VR display to experience the environment through a single-user mode. As the user's navigation of the VR environment was projected to an external screen, we were able to screen record the VR experience from a third-person's point of view. These data were analyzed descriptively, in order to understand each student's learning performance and experience.

Immersion and conceptual gains questionnaires: Upon completing the VR activity, each student responded to the Virtual Reality Immersion (VRI) questionnaire which was an adapted version of the Augmented Reality Immersion (ARI) questionnaire (Kyza & Georgiou, 2017). The VRI comprises of the Total Immersion scale, which has two subscales: Flow (3 items) and Presence (4 items). All items were evaluated on a Likert-scale from 1-7. In addition, a conceptual understanding test was administered to assess students' learning about the concepts related to the topics of the VR investigation. The conceptual understanding test included eight multiple-choice items and four open-ended questions, and had a maximum score of 10. The data collected with the immersion and conceptual gains questionnaires were analyzed to create a quantitative indicator for experienced

immersion as well as a quantitative indicator for learning for each student, which provided a numeric estimation of students' total immersion and conceptual understanding.

Post-activity interviews: Each student participated in an individual, thirty-minute, semi-structured interview after the intervention. Students were prompted to discuss their feelings of presence and flow, as well as the factors which had positively or negatively affected these feelings. Interviews were qualitatively analyzed using the Critical Incidents Technique (Flanagan, 1954). With this approach we sought to identify and contrast specific incidents which could be conceived as factors shaping students' immersion and learning.

Findings

Learning performance

When examining the students' learning performance, we find that both visited the learning stations within the fixed duration of thirty minutes, and that they viewed all the available multimedia resources. However, only Susan successfully completed the inquiry-based mission and specified the correct era of the wall mosaic. Susan's investigation lasted 28:17 minutes, while Tom's investigation lasted 24:10 minutes; the additional time in Susan's case was invested on the inquiry-based exploration of the church.

Quantitative indicators of learning and immersion

The examination of students' immersion indicators showed that Susan achieved higher levels of immersion, especially in terms of presence. More specifically, Tom's sense of presence was relatively low, while Susan experienced a higher sense of presence. Likewise, the examination of students' learning indicators showed that Susan achieved higher learning gains than Tom, especially in terms of conceptual knowledge.

Qualitative accounts of experienced immersion

Tom's interview suggested that while the VR environment captured his interest, there were three main barriers which negatively affected his sense of presence: (a) usability issues related to his navigation in space, (b) the multimedia learning resources which were perceived as "distractors" compromising the fluid progress of the game play, and (c) the limited sense of embodiment due to the lack of full-body interaction. On the other hand, Susan reported that the VR environment not only captured but also maintained her interest, resulting in a high sense of presence. We identified three main factors which positively affected her sense of presence: (a) the overcoming of usability issues, (b) the multimedia learning resources which served as "focal" points due to their audio-visual properties, and (c) a sense of embodiment due to the realism/authenticity of the environment.

Conclusions and implications

This work contributes empirical substantiation to the subjective nature of immersion as well as to its positive relation to the learning process. The findings are aligned with prior studies which support the claim that immersion is a subjective human experience, which may be mediated by learner characteristics (Georgiou & Kyza, 2017, 2018). For instance, differences in learning styles between the two students could provide a plausible explanation regarding their different perceptions of the VR environment. Likewise, it might be that students' digital skills may explain the persistence or overcoming of usability issues. Put simply, learner characteristics and personality traits may define students' immersion and subsequent learning. Our future work will explore these issues more systematically, given that this case study is part of a broader research effort that includes 50 additional students. Our next steps will focus on the analysis of the collected data for the extraction of more generalizable findings.

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