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Integrating Immersive Technology into Small Group Learning Environments

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Abstract: The goals of this study were to explore (a) whether students learn critical STEM content through group activities that integrate immersive virtual reality (VR) with more traditional digital simulations, and (b) whether choosing to use VR affects students' learning and their perceptions of the activity. The results indicate overall improved pre-post learning outcomes for students in multiple sections of a college astronomy course who participated in the multi-device activity.

Introduction

Technologies such as large multi-touch display surfaces have been shown to be effective for facilitating collaborative learning (e.g., Mercier & Higgins, 2013), but immersive technologies such as augmented reality (AR) and virtual reality (VR) are assumed to have more utility for individual learners and have been used less frequently for collaborative tasks. Numerous studies in recent years have shown that using immersive technologies to alter student perspectives with digital overlays and simulated environments can improve individual learning outcomes in a range of learning domains (Checa & Bustillo, 2020; Concannon et al., 2019; Ibáñez & Delgado-Kloos, 2018). What has been less explored is whether single-user immersive technologies such as VR can be integrated productively into a small group learning activity involving other technologies with different students adopting different perspectives and taking on different roles.

In the current study we looked at a collaborative learning task situated in an undergraduate introductory astronomy course. Students who worked on this task were given many resources including tablet computers and a single VR headset that all tapped into the same set of star models, but with each technology having different affordances for exploration and perspective-taking. The goal of this preliminary study was to understand: (1) Do the individual students participating in this task learn the desired content? (2) Is the amount of time spent using the VR related to the subsequent learning outcomes? (3) Is the amount of time spent using the VR related to the students' attitudes toward the learning task?

Software environment and the tasks

The software enables group members to share observations and annotations of the night sky across both VR (Oculus Quest headsets) and tablet PCs (Microsoft Surfaces) while maintaining a consistent interface and representation of the night sky. Three main views are provided within the software: star view, horizon view, and Earth view (see Figure 1). Horizon view allows for the observation of the night sky from a specific location, date, and time. Earth view allows observe the Earth from above while dropping pins to change their location and obtain latitude and longitude coordinates. Star view provides an explorable view of the full celestial sphere and catalogued western constellations.

The task "Lost at Sea" has students using their observations of the night sky to determine the location of a crewed space capsule that has splashed down at night somewhere on Earth. Groups of students must first identify features of the night sky to determine which hemisphere the capsule is located in (Task 1), then identify familiar constellations to use as reference points (Task 2), then refine their location estimation through the calculation of both latitude (Task 3.1) and longitude (task 3.2) using the night sky.

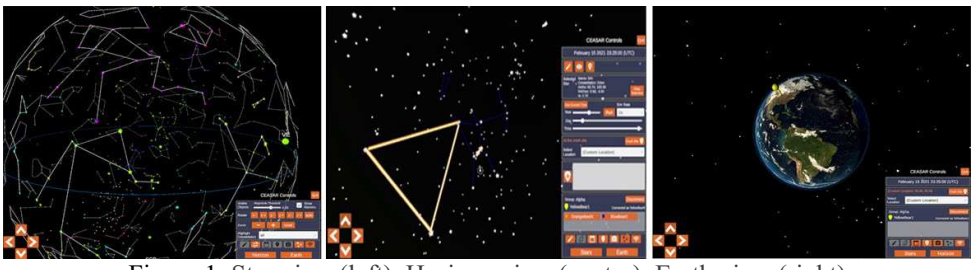

Figure 1. Star view (left), Horizon view (center), Earth view (right)

Participants and measurements

The participants were 33 college students recruited from a subject pool at a community college in the mid-western United States. All students were taking the same introductory astronomy class and were asked to voluntarily form a group of three to four students to work on the tasks collaboratively. Most of the groups spent about 60 minutes to solve the tasks together. One VR and two tablet devices were provided to each group and a pre/post-test and post-questionnaire were completed individually by all participants in the study.

The paper-based materials consisted of a pre/post-test and post-questionnaire. Pre/post-tests were conducted to measure changes in students' knowledge of the procedures involved in calculating latitude and longitude based on the night sky. The question asked in both tests was the same: "Write as much as you know about the steps for calculating latitude and longitude based on the stars visible in a given location." The tests were scored for correctness and complexity on a 0 - 2 scale. All scores were calculated independently by two research personnel and the results were exactly consistent with each other. In addition, the post-questionnaire asked students to make self-ratings on a 5-point scale of statements of perceived difficulty for each task and statements of evaluating the VR simulations. It also contained a short-answer question about how long they had used VR.

Results

For the *first research question*, Wilcoxon signed rank test was conducted on the pre- and post-test scores of each student and the result shows that there is a significant difference in the means from pre- to post-tests, with gains for both latitude ($W = 153$, $Z = 4.07$, $p < .01$, $r = 0.71$) and longitude ($W = 45$, $Z = 2.99$, $p = 0.01$, $r = 0.52$). For the *second research question*, a one-way ANOVA revealed no significant differences for both latitude and longitude, but weak negative correlation has been found for latitude (-0.22). In addition, a simple linear regression was calculated to predict perceived difficulty based on the time spent on VR found that the longer students used VR devices, the more difficult they perceived Task 1. For the *third research question*, a simple linear regression was conducted. As summarized in Table 1, the results showed that the longer students use VR, the more positive they evaluated the VR simulation experience.

Table 1: Students' rating of VR simulation

Post-Questionnaire Item	F	*p*	Correlation
"The VR simulation was useful in completing the task goals"	3.97	0.06	0.34
"I would like to learn with VR in the future"	3.98	0.05	0.34
"I felt happy while using the VR simulation"	6.83	0.01*	0.42
"I felt excited while using the VR simulation"	7.37	0.01*	0.44
"I felt bored while using the VR simulation" (reverse scored)	7.09	0.01*	0.43

Discussion

We acknowledge that having a small number of participants and the absence of a control group are limitations. However, the evidence of overall positive learning outcomes measured via the pre- and post-knowledge assessment indicate that individual students extended their existing astronomy knowledge while engaging with novel technologies and modes of interaction. Significant correlations of time in VR with self-reports of positive affect support the role of VR as an engaging tool in the learning process for this set of astronomy tasks. In addition, the perception of increased difficulty for Task 1 for those spending more time in VR, but not for Task 2 or 3 may be an indication that acclimating to the novel technology environment could be impeding initial learning. To address this, revisions of both the task and the software to provide appropriate and timely scaffolds that assist the learner with using the immersive environment will be critical to ensure productive collaboration and learning.

References

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