Interplanetary Space Exploration Virtual Environment for Kids

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Background

The importance of STEM education has gained attention in recent years. However, the shortage in qualified employees in the STEM field has raised concerns on a national level (Street *et al*., 2012). The transdisciplinary nature of STEM education requires a higher level of cognitive skills from students, which decreases students' motivation for learning STEM. For instance, the ability of spatial and abstract thinking needs to be present simultaneously when children are learning 3D geometry (Lei *et al*., 2018). The extensive requirement of cognitive abilities leads to students experiencing higher rates of failure, which significantly decreases student enthusiasm in pursuing STEM education (Holly *et al*., 2021).

In light of facilitating educators and improving students' STEM education outcomes, many researchers are exploring the possibilities of incorporating virtual reality (VR) technology in STEM education. First, lessons are done in immersive VR environments, which significantly increase their motivation, interest, and engagement (Parong & Mayor, 2018). Increased motivation causes learners to stay better focused during long periods of learning, and therefore better tackle more cognitively challenging subjects such as STEM. In addition to elevated motivation levels, VR could make STEM learning more achievable to students. One study has shown that students who learned about the force of friction in an IVE lab demonstrated significant improvements in understanding and applying the concept (Lei *et al*., 2018). The IVE lab makes abstract knowledge such as friction more concrete for students to observe, therefore reducing the cognitive requirements from students and enhancing learning outcomes. Another similar study has shown that VR education can be beneficial for older students to acquire STEM knowledge as well. In the study, the "Maroon Lab" was developed in order to educate students about the concept of induction and diffraction. (Holly *et al*., 2021) Special affordance allowed students to not only see the magnetic fields, but also have an opportunity to feel the acting forces through vibrations generated by the equipment.

Method

Virtual Experience Overview

As we are designing the interface, the experience and virtual environment to be kids between the ages of 8 and 13. The user's avatar won't be presented. All scenes and interactions will be experienced through a first-person perspective.

Secondly, we will be creating an embodied agent, Gloop, that looks like a robot, which can help kids to navigate and be like a guide for them throughout the trip. We want to utilize the possibilities of having this embodied agent in IVE because the embodied agent could encourage construction instead of consumption of the knowledge (Bailenson *et al*., 2008). Additionally, the embodied agent could provide young users a sense of peer learning instead of studying under the pressure of an authoritative teacher figure. (Bailenson *et al*., 2008)

In this virtual space exploration, the kids will be able to select a planet which they want to explore first and then will be teleported from one planet to the other using the teleport functionality. After landing on the planet, kids will be exploring the planet's surface accompanied by Gloop, who teaches about the various environments. Users will encounter volcanic eruptions scenes on Mars to visualize and learn about the Olympus Mons, the biggest volcano in the Solar System. Then, they will be cautioned about the safety and be redirected by Gloop back to the ship, where they will choose another planet to teleport to. Students will then explore and learn about Venus's environment. After the initial exploration stage, a simulation of acid rain will trigger, which leads the kids back to their spaceship, and then the journey takes them forward to Uranus. On Uranus, the users will see the frozen plain and Gloop will explain Uranus' inhabitable environment. Afterwards, the user will be teleported back to Earth, which concludes the entire experience.

The reason we chose to develop the experiences of the solar system instead of a more generic environment was to exploit the various special affordances of IVE. IVE could enhance visualizations and present complex information from different perspectives (Bailenson *et al*., 2008). Holly *et al*. (2021) also pointed out that the VR can provide users an opportunity to visualize invisible phenomena when learning, which facilitates better content comprehension. Most importantly, IVE is to provide an opportunity for learners to learn through interacting within dangerous or impossible scenarios, such as exploring outer space (Bailenson, 2018). We also made sure to only present essential objects per scene to reduce system latency to minimize motion sickness (Bailenson, 2018). We also included audio over “Gloop” to explain the scene for the users to provide multi-sensory experiences in IVE (Sanfilippo *et al*., 2022).

Due to the young age of our target users, special caution was observed throughout our design. According to Bailey and Bailenson (2017), it can be challenging for children to realize their physical environment while wearing an HMD device. Based on the above research, we chose to let users teleport to different planets to minimize the walking motion. Furthermore, children may experience more intense emotions in a fully immersive environment due to lack of understanding of media representation (Bailey & Bailenson, 2017) In our project, we made sure that the disaster scenes presented are not too realistic so as to not overwhelm younger users.

Equipment

In this project, we utilized Unity as our VR module to build the scenes of spaceships, Gloop, Venus, Mars, and Uranus and their environments. A head-mount device, the Oculus 2 VR headset, along with 2 joysticks, will be the primary tools that users would interact with. The Unity Development Engine allows easy stereo rendering in HDM, which has a large impact on users' sense of presence in the virtual environment (Spanlang *et al*., 2014). In addition, the Oculus 2 VR headset has a built-in head tracking module. A markless optical and inertial system within the headset could update the virtual camera and change the user's viewpoint based on their head movements (Spanlang *et al*., 2014). When experiencing the environmental changes of different planets, users would have a more realistic view of the scenes, such as volcanic eruptions and acid rain. Moreover, the headset is also used as a display module, allowing users to see different environments of selected planets at any given moment. Additionally, the Oculus 2 does a good job in blacking out the physical environment that the user is in to provide them with a better immersive experience (Spanlang *et al*., 2014).

Measures

(i). Level of presence and immersion

Sense of presence is an important factor to measure the IVE success (Cummings & Bailenson, 2016). To measure the sense of presence, we will use both objective and subject measures for this project. (IJsselsteijn *et al*., 2000). Objective measures will include a post-experience questionnaire with a rating scale to let users rate their sense of presence toward the experience. Our team will use a reaction log to keep track of the user's response to each scene they are going to explore as a subjective measure. The reaction log is divided into 2 categories: physical reactions such as head movements, hand movements, and whole body movements, and verbal reactions such as comments on the scene and description of experience. We will assess the level of immersion by calculating how frequently users react to these scenes.

(ii). Learning

Since the objective of our experience is to teach users about different planets' environments, a post-experience assessment will be given immediately after the experience to measure how much knowledge that users have gained and retained (Holly *et al*., 2021). The assessment contains 2 questions.

1. What planets did you explore today?
2. What did you learn about Mars, Venus, and Uranus?

Discussion

We predict that younger users will have higher motivations to learn about the different planets and their environments. Additionally, we predict that the user's learning outcome would be greater compared to learning through a traditional classroom setting. We make such predictions based on the previous success found in other studies and incorporating special affordances presented in our project. Firstly, the nature of the immersive experience of this project would help students better visualize the plants' environments in contrast to traditional media, such as pictures and videos (Bailenson *et al*., 2008). Additionally, the 3D models of planets and environments would enhance the students' sense of presence

(IJsselsteijn *et al*., 2000). Interactions with the environments and the embodied agent occurring in different scenes would encourage users to move their bodies and hands, which would enhance learning results (Bailenson *et al*., 2008). Lastly, the interaction with the embodied agent “Gloop”, acting as a companion and teacher to younger users, would encourage active learning by exploring the environment. Young learners benefit from learning from a friendlier figure than a more authoritative teacher figure (Bailenson *et al*., 2008).

We want to explore how users of different age groups would react to the designed experience differently through this project. Although our target user is between the age 8 and 13, we would like to learn how the IVE learning experience affects even younger users. Since it is unclear whether it is valuable to implement IVE in education for young learners, we hope this project would help us answer the question. Additionally, we want to explore how the sense of presence in IVE would impact the user's learning outcome. Would users who reported having a higher sense of presence have a better learning outcome in contrast to those who have a lower sense of presence?

Since the project only lasts about two months, we don’t have time to conduct more in-depth user research. For example, we would like to know what teachers struggle the most in class when teaching the planet’s environments and what interactions that would excite students the most. We would like to recreate scenes that match both the teachers’ and students’ needs. Additionally, it is beneficial to do early testing on users to determine what kinds of embodied agents would best attract their attention. We would also like to determine what level of realism of scenes would improve student learning without causing an extremely emotional reaction.

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