VR instruction and the associated impact on student learning
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Abstract

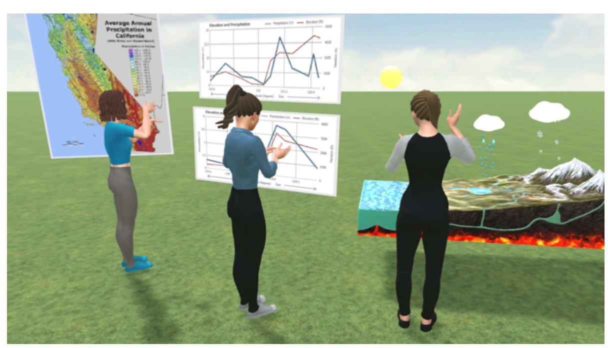
Twenty-two 6th grade students, participated in a 6-week instructional intervention leveraging synchronous virtual reality based experiential learning opportunities supported by asynchronous readings and assignments. During instruction, students were physically present in a traditional classroom environment, with teachers delivering instruction from a remote location. After an initial week of VR training, students began five weeks of instruction targeting NGSS grade level earth science standards and the associated Science and Engineering Practices. Students met for one hour each day, four days per week, for a total of 20 contact hours. Each day consisted of a 15-minute check-in via zoom, followed by a 45-minute VR-based experience. Initial focus interviews reveal low levels of prior knowledge related to the targeted concepts, and all students achieved proficiency for all standards during the intervention. Student achievement was assessed using a capstone project. Additional findings include 1) Students reported a preference for VR instruction, 2) the adaptability of the model to meet the needs of all learners and 3) a perceived sense of community extending beyond that of a traditional classroom, and 4) an increased level of student engagement with content.

Introduction

Currently, the most common model of VR-supported learning provides students with an experience in the headset, and then students leave VR to receive the instruction. This intervention is unique in that researchers delivered the instruction in the headset during the experience. Researchers believe this distinction is critical to student success. Imagine sending students to the Air and Space Museum to explore the facility independently. Now imagine a more traditional field trip where a class of students experiences the same museum with their peers and a guided tour with a content area expert. In the first example, learning is an isolated, lonely experience similar to that of most self-paced distance learning opportunities. In the second scenario, the learning experience is truly a guided inquiry, allowing for social learning derived from a shared experience. The VR content delivered during this intervention was specifically designed to capitalize on the benefits of social learning and foster a sense of community amongst learners and teachers.

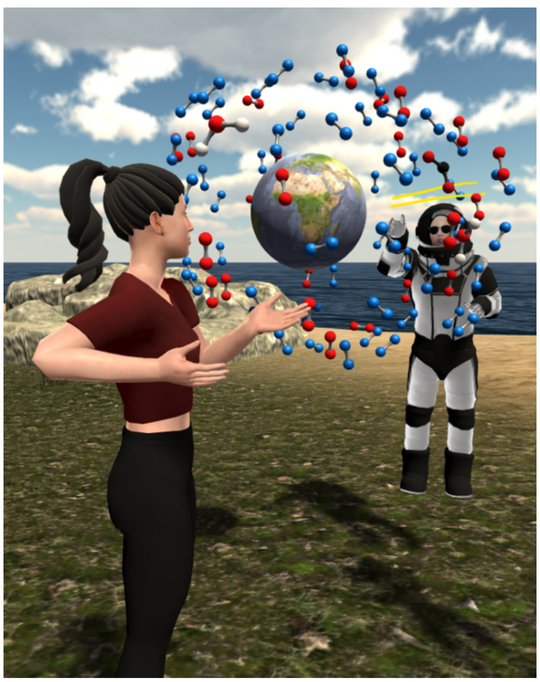
Background Research

Students' interest can be primed with VR learning while still being an effective medium to convey scientific content comparable to traditional PowerPoint slideshow lessons (Parong & Mayer, 2018). Research shows that learning VR leads to higher levels of presence, which is related to higher levels of interest. VR can cause students to become more interested in the material, which leads to higher levels of engagement and learning gains that are manifested in better performance on long-term assessments of learning (Makransky & Mayer, 2022).



Methodology

The VR experiential learning opportunities were designed to maximize the best VR has to offer. Traditional classroom activities such as lectures, assigned readings, and note-taking were intentionally excluded from the VR experience. Researchers intentionally designed instruction to maximize the benefits of VR and minimize the number of time students was spending in headsets. Each experience had a maximum of 10 minutes dedicated to explanation and presentations. The remaining 35 minutes were focused on exploration or collaboration. Examples include student-centered Socratic discussions, investigations, field trips, student-derived models, and creative expressions. Instruction in the VR setting models that of inquiry-based teaching techniques where Teachers circulate between the small groups guiding instruction instead of dispensing information. All instructional components were recorded and reviewed by an expert panel as part of our program. Student-level data were collected as part of regular classroom practice, including classroom assignments, discussions, and interviews.



The initial design of asynchronous work had detailed units and student assignments that supported the VR experience; however, prior to this instructional intervention, our students were not required to do any homework outside of class time. With our limited timeline, researchers chose to abandon out-of-class activities allowing students to complete abbreviated assignments in the first 15 minutes of class time. Throughout the intervention, students began completing assignments and readings prior to class to maximize VR instructional time. The Learning management system played a crucial role in communication between students and teachers. Video feedback was strategically used to support the sense of connectedness and build relationships between teachers and students. Targeted comments on student work were used to promote student thinking and transition students between concepts. Researchers were intentional about using these tools to promote intrinsic motivation towards content and future investigations and establish meaningful connections that extend beyond the VR learning environment.

Curricular resources were designed to align NGSS earth science standards for 6th grade. All student-centered investigations supported the associated Science and Engineering Practices (SEP). Table 1 provides an overview of lessons, the delivered targeted standard, and the SEP alignment. Each lesson was delivered over the course of an academic week, including 4 class periods and an estimated 4 hours of instruction time. The VR experiences for each lesson were specifically chosen to expose students to different learning opportunities in the VR environment. These learning opportunities include but are not limited to virtual field trips, 360° videos, interactive models, virtual recordings of content area experts, and simulations or enhanced 2-D videos.

Table 1 Lesson alignment to NGSS content standards

Lesson	NGSS Standard		Sci & Engineering Practices
Water Cycle	MS-ESS2-4	Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.	Developing and Using Models,
Local Weather	MS-ESS2-5.	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.	Asking Questions and Defining Problems, Planning and Carrying Out Investigations, Using Mathematics and Computational Thinking
Solar Radiation	MS-ESS2-6.	Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.	Developing and Using Models, Using Mathematics and Computational Thinking
Weather and Climate	MS-ESS3–5.	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.	Developing and Using Models, Analyzing and Interpreting Data, Engaging in Argument from Evidence
Human Impact	MS-ESS3-3.	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	Constructing Explanations (for science) and Designing Solutions (for engineering), Obtaining, Evaluating, and Communicating Information

Student achievement was assessed using both formative and summative assessments. Daily formative assessments provided instructors with diagnostic information related to student achievement. This information allowed the teachers to modify their instructional approach to ensure student progress towards instructional objectives. Summative assessments were modeled off on a traditional project-based approach to assessment. This final project provided students with a capstone experience, allowing them to showcase their newly acquired VR skills and the content knowledge they have acquired over the course of the instructional intervention.

Results

Findings from this case study are reported with respect to four overarching categories. 1) Students reported a preference for VR instruction, 2) the adaptability of the model to meet the needs of all learners and 3) a perceived sense of community extending beyond that of a traditional classroom, and 4) an increased level of student engagement with content.

Student preference:

As part of a classroom discussion, students were asked to tell us about learning in their VR experience. Of the 18 responses, 14 described learning in VR as fun. Several of these students also identified aspects of the learning environment that were favorable.

"I like learning in VR because it is really fun exploring new worlds";
"I really enjoy learning in VR; you can see things happening";
"Learning in VR is more fun, and it is easier to focus."

These responses specifically refer to the experiential learning aspect of the class. Another student specifically mentioned that they want to learn more about how VR works. Only one of our participants mentioned any physical discomfort.

"Learning in VR is fun but sometimes I get dizzy"

Teachers monitored her during VR activities for this student and encouraged her to reduce her range of unrestricted motion by using teleportation for locomotion. Throughout the course, very few students experienced motion sickness. There were no negative comments related to learning in VR.

"Learning science in VR is better because you can see how everything comes together not like on the computer"

This quote addresses the reality of VR. Students can experience abstract concepts in a very concrete way. For example, this student was describing her experience learning about the greenhouse effect. In this lesson, students modeled the greenhouse effect and its ideal composition of molecules. By adding individual carbon dioxide molecules, they were able to visually represent an increased efficiency of the greenhouse effect to trap heat and drive an increase in global temperature. This is a hard concept to communicate in a two-dimensional computer simulation. This student actually laid their hands on carbon dioxide molecules and documented the corresponding increase in temperature as she added anthropogenic carbon.

Adaptability of the model:

The instructional model implemented during this intervention was designed as a distance learning platform. The intended participants would be part of a distance learning community, including both virtual and homeschool students. When presented with the opportunity to implement the project in a traditional brick-and-mortar classroom, researchers pivoted and experienced very minor technical challenges. The most significant adaptation to meet the new model required the implementation of headphones to cut down on classroom noise. Our participant school had a long-term sub hired to fill the sixth-grade science teacher position. Our instructional intervention provided a certified science teacher to deliver the content remotely. Only basic IT support was required to operate during the implementation of this program.

By leveraging both a zoom class meeting, a learning management software, and the Engage VR Learning platform, teachers were able to track student participation and performance closely. In one case, during a zoom portion of the class, the instructor observed a student struggling to complete a short reading assignment. The instructor was able to send an instant message through the LMS system differentiating instruction to accommodate the students' unknown challenges related to processing written language. The student completed the required task and joined her peers, and made significant contributions during the VR learning experience. After making this initial discovery, the instructor learned that the student did not have documented accommodations but faced challenges as an English language learner. After receiving support from the teacher, this student's participation increased.

The model of instruction delivered during this intervention has the ability to deliver high-quality instruction that is flexible enough to differentiate instruction, meeting the needs of a diverse student population. Even though this technology was developed to replace distance learning platforms, deployment of this technology into traditional brick and mortar schools offers excellent potential to provide relief from our national teacher shortage problem.

Sense of community:

As part of the instructional design, researchers provided students with prompt and relevant feedback on all written assignments. Identified as a best practice for online instruction and often cited as a shortcoming for traditional distance learning platforms, teachers used several different tools within the learning management system to communicate with students. This includes not only feedback during grading but also class announcements and instant messenger. The VR learning environment offers a unique opportunity for students to build relationships, much like in a face-to-face environment. Researchers have noticed that even reserved and quiet students are often more likely to ask for help as an avatar than they would in a traditional brick-and-mortar classroom. Furthermore, students in our sample were highly eager to participate in discussions and answer questions presented by the teacher. We believe that this is likely linked to a reduced level of academic anxiety cultivated in this learning environment. External reviewers identified that the instructor's positive attitude and constant supportive nature likely contributed to this decreased anxiety and increased student participation.

The collaborative element of the curriculum design supported not only peer-to-peer interaction but also played a critical role in the delivery of science and engineering practices. Students participated in activities as a community of scientists. Regularly students shared their small group projects with the whole class as part of a large group discussion. Over the duration of the course, excitement for the sharing opportunities increased as students became more comfortable communicating their ideas to the group. The improvement in communication and soft skills observed by the teacher was likely a product of this unique learning environment, but more importantly, it became a part of the classroom culture. External reviewers documented an increase in peer-to-peer encouragement and empathy that corresponded to this sense of connectedness.

Student engagement:

Initial focus group interviews with participant students were used to assess prior knowledge related to the targeted standards. Findings revealed minimum levels of understanding of the targeted weather and climate NGSS standards and the Science and Engineering Practices. This content presents a unique challenge with respect to teaching and learning. Beyond the persistence of politically charged opinions related to anthropogenic climate change, there are several known misconceptions related to these topics. These challenges, along with the esoteric nature of this content, make it ideal content for the delivery of instruction in VR. Participant students exhibited an increased interest in the material, developing their own questions and topics for investigation. These results confirm earlier research findings related to VR instruction increasing students' intrinsic motivation for learning (Makransky & Mayer, 2022). Additional evidence to support an increase in intrinsic motivation towards the content can be found in the students' willingness to contribute to group discussions and respond to teacher questions. External reviewers identify that all students displayed an eagerness to participate. This finding was described in contrast to the lack of participation found in most other learning environments, both traditional and distance.

Daily readings and assignments were delivered through a learning management system. As mentioned earlier, a slight modification to the instructional design reduced these assignments to smaller in-class activities. Students arrived at the classroom, logged into canvas, and completed their asynchronous activity. Upon completion, they would raise their hand, and the remote instructor would confirm they received the submission in the LMS. At that time, the instructor would release the student to retrieve their headset and proceed to the VR learning environment. Requiring students to complete this task in order to access VR encouraged 100% participation in assignments. In most cases, these assignments did not present significant challenges, but they were designed to provide essential background information that is needed for success during the VR experience. This daily work could be considered a pre-lab. Student growth was monitored using formative assessments during VR instruction. These formative assessments allowed teachers to differentiate instruction to meet the needs of individual students. Summative assessments resemble that of a traditional project-based learning assignment. For this assignment, students created a VR recording, explaining in detail the critical elements of topics presented in the NGSS standards. These recordings resemble that of a simulation or model designed to teach complex scientific content. Projects were evaluated using a modified rubric designed to evaluate a written report. Revisions included a criterion to assess the student's use of VR manipulatives. 100% of students scored at or above proficient on all NGSS standards.

As part of this instructional intervention, we welcomed both administrators and teachers from the district to join our VR learning environment and observe instruction. After class, researchers commonly spoke with our visitors about their experience and perception of VR instruction. One of our frequent visitors was a teacher at the school. This teacher was impressed with the quality of instruction and the level of engagement and work ethic exhibited by the students in his own words.

"During these five weeks you have easily covered a semester worth of content. And these kids really know it. I speak to them outside of class and they really know the information".

Discussion and Implications

This case study confirmed the effectiveness of VR technology in delivering high-quality instruction and cultivating and sustaining a rich learning environment and adapting to meet the needs of individual students. The model delivered as part of this instructional intervention shows promise as a means to alleviate our national teacher shortage problem in hard-to-staff positions such as science and math teachers.

VR curricula and virtual field trips provide students an opportunity to explore a world beyond their own. This includes not only traveling across distance, space and time but also bridging a gap in instruction by connecting abstract ideas to concrete learning opportunities. For example, students can explore the great barrier reef, learn about ocean acidification then immediately jump to an inner-city to talk about the influence of burning fossil fuels on acid rain.

References

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