WIP: Turtle VR: Virtual Reality Field Experience for Geological Engineering Education Enhancement

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***Abstract*—At colleges and universities, majors ranging from geology and ecology to environmental and agricultural engineering rely on field experiences to train students in settings outside of the classroom. These field trips are not only costly, but they might also raise safety and accessibility issues for students and increase burdens on overworked faculty. This paper describes a virtual-reality (or VR) experience that utilizes an interactive narrative to meet student learning outcomes as an affordable complement to field trips. The Turtle VR experience was developed using Unity for Metaquest VR headsets. The experience consists of three modules that guide students through a real-life scenario of collecting and testing data related to the preservation of sea turtles. We conducted a user study to collect feedback from 34 students. Participants were asked their opinions on the VR environment, as well as completing pre- and post-intervention quizzes to assess learning outcomes. Concluding this study, the feedback was overall positive: results from the pre- and post-quizzes showed that 63% of users saw an increase in scores, indicating that students acquired new knowledge from the VR experience. Additionally, the post-survey revealed that approximately 87% of students enjoyed the experience, and a majority of them did not experience the common discomforts caused by VR (headache, nausea, dizziness). Moreover, 74% of users reported that they wanted to learn more about the subject. The study revealed that most students involved were pursuing STEM disciplines, primarily in computer science, highlighting Turtle VR's success in engaging students outside the field of geology with geological science. The results suggest that utilizing a narrative approach in VR learning experiences does not impede learning yet increases enjoyment. Narrative frameworks can be redesigned to cater towards other engineering students. With this VR application, engineering students would be able to get a more hands-on approach to the underlying fundamental concepts in field settings, instead of learning about it through standard lecture materials such as PowerPoint presentations. Since the results of the aforementioned study were overall positive, this VR application has the potential to improve education in geological engineering education.**

This material is based upon work supported by the National Science Foundation under Grants #IUSE-2142428 and #IUSE-1730568. All study activities were supervised by ECU's IRB office.

***Index Terms*—Virtual Reality, Geological Education, Geological Engineering Education, Field Experience**

I. Introduction

A career in geological engineering requires students who quickly adapt to the vastly changing field, get adequate hands-on experience, and are creative thinkers [1]. These prerequisites are difficult for professors or other college and university faculty to educate their students on using traditional lecture-based teaching methods because they are usually taught using field trips where students perform these tasks themselves [2] [3]. These field trips can be expensive and raise safety issues for the students, and may not be accessible to others [4]. Turtle VR is a virtual reality program designed to tackle these field trip challenges and educate students about the environmental problems surrounding the world such as beach modification, light pollution, and plastic pollution [3]. When considered collectively, these three problems have an adverse effect on turtle populations, underscoring the significance of educating people about this subject [5].

Utilizing the underlying framework of Turtle VR, we can revamp the modules to enhance engineering education, catering to the needs identified in our user study, which suggest a reduced reliance on field trips [4]. It is important for rising engineers to have experience with field work before entering their careers [6]. The engineering field is vastly growing and changing, as well as becoming a competitive workforce, so hands-on experience can be imperative for job opportunities [6] [7]. Furthermore, hands-on experience can enhance the skill set of aspiring engineers while also offering novel learning outcomes [6]. Overall, adapting Turtle VR to focus on engineering education has the potential to offer numerous benefits to future engineers.

In this work-in-progress paper, we illustrate the fundamentals of education using Turtle VR, the enhancement in student learning achieved throughout the three modules in the

program, and the design of the program that can be remodeled to improve engineering education.

II. Related Work

Education enhancement and seeking an alternative to field trips using VR systems is a widely researched subject. In 2020, there was a study held to explore the role of field trips in geoscience education [8]. The study compared the learning outcomes and experiences of students attending actual field trips, students experiencing a field trip through a desktop simulation, and students experiencing a field trip through an immersive VR device such as the Meta Oculus Quest. Students were given an introductory geoscience lab module, involving a field trip exercises in order to educate them on geological features and the depositional environment. The actual field trip group visited the Salona Formation, and the VR groups used 360° imaging of the site as well as additional information accessible through icons within the images and audio narrations. Both VR groups completed various tasks to simulate what would be done on the actual field experience, such as measuring rock layers in a 3D model of the formation. Results from this study conclude that both groups of students experiencing the VR field trips scored higher in learning experience and perceived outcomes than the group of students attending the actual field trip. Furthermore, the students in the immersive VR group reported higher motivation and presence than those in the desktop simulation group, but there was no significant difference in learning outcomes between the two groups.

Another study done in 2019 outlines the importance of developing pedagogies and evidence-based design principles for immersive learning in the geosciences [9]. The study seeks to explore the possibility of VR field trips supplementing or replacing actual field trips by taking two groups of students for a qualitative analysis of both environments. To simulate the actual field experience, the group in the VR environment were provided technology that used high-resolution images, 3D models, and interactive elements. Each student was given a series of pre- and post-assessments, such as questionnaires and lab assignments, to evaluate the learning outcomes and experiences of the students in both groups. Results from the study conclude that the VR field trips positively impacted learning outcomes and experiences, as well as increased engagement and enjoyment when compared to actual field trips. Moreover, students in the VR environment did significantly better on the spatial situation models compared to the students on the actual field trip. The group experiencing the field trip through VR valued the convenience and focused learning provided through the virtual world, while the group on the actual field trip showed appreciation towards the hands-on experience and autonomy.

The VR techniques explored through these studies significantly benefit the enhancement of geoscience and engineering education involving field trips. In our project, we implement similar methodologies such as pre- and post-assessments, however we also integrate a student-centered learning framework which very few other studies have done to the best of our knowledge. Turtle VR aims to provide a valuable resource to geoscience and engineering education through the combination of the aforementioned VR techniques and our student-centered pedagogical approach.

III. Approach

Turtle VR was designed with the following objectives:

1) Implement a student-centered learning experience [10] for hands-on turtle environment education;
2) Provide students an educationally exceptional alternative to field trips with three different situations pertaining to turtle protection;
3) Develop a foundational program adaptable for engineering-focused modifications to enhance engineering education.

This provides students with a real-world, hands-on experience from the safety and comfort of a classroom using a commercially available virtual reality headset (designed for Meta Oculus Quest 1 and 2) [3]. It allows the user to complete each module at their desired pace, with the freedom of deciding their learning path, while also minimizing the need for an instructor with geological expertise [3] [4] [11]. The structure of this learning platform can then be remodeled to potentially improve engineering education.

A. Student-Centered Learning

One of the main goals of this program is to implement a student-centered learning environment to provide a safer and affordable alternative to field trips. This would allow students to complete the experience at their own pace and in any order they would like [4] [11]. Turtle VR provides the user with the tools they need to navigate throughout the virtual scenario, which can be applied to a real-life problem [3]. With the student-centered learning experience implemented at its core, Turtle VR is designed to reduce the need for an instructor to provide students with a real-world scenario relating to what they are learning [3] [4]. Students would be able to attend the virtual field experience, be lectured on the module topic they chose, and complete the experience in their own time [3] [4] [11].

B. Module Design

The learning environment provided by Turtle VR guides students through a real-world problem and educates them on the importance and impact it has on the local turtle population. Each module presents the user with a short lecture/presentation of all the relevant material they need to know for the experience. They are then exported into the virtual site, replicating a real-life scenario pertaining to the module they choose. The modules, all relating to the preservation of turtles, include:

- **Plastic Pollution:** Users take soil samples from across a beach using a sampling tool modeled after one used in real life. They then return to the lab to analyze the samples and observe the abundance of non-organic material in each sample [12].

Fig. 1. The user is faced with a contaminated beach setting, enabling users to collect soil samples.

- **Beach Modification:** Users take measurements of a beach to determine how man-made concrete structures affect our beaches. The introductory lecture and the lab teaches them about identifying the different types of beach modifications and how to calculate sand displacement using geometry [12].

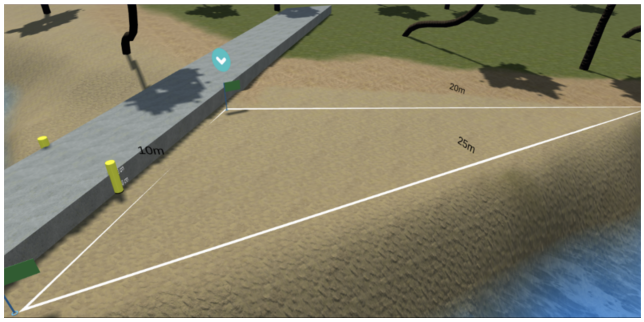

Fig. 2. The user uses measurements to investigate the impact of man-made structures on the beach environment.

- **Light Pollution:** Using a lux meter, users take lumen measurements of multiple sources of natural and artificial light from around a beach and the program explains how these sources of unnatural light affect local wildlife and ways to avoid obstructive uses of artificial light [12].

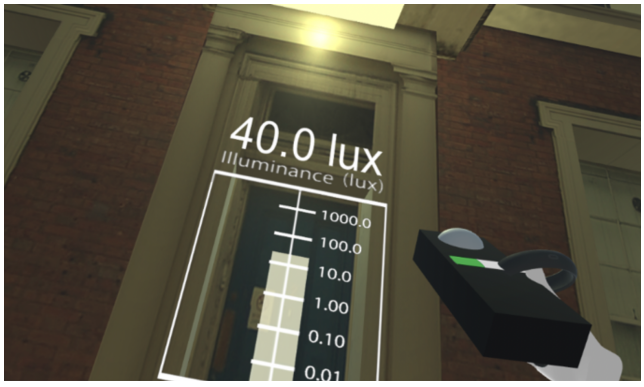

Fig. 3. The user takes a lumen measurement from an artificial light source (a light bulb).

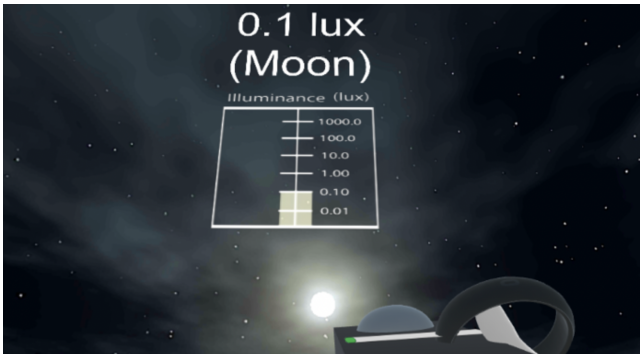

Fig. 4. The user takes a lumen measurement from a natural light source (the moon).

Following each of these experiences, the program exports users back to a virtual lab where they can test their samples and/or answer quiz questions based on the module they chose. For example, the Beach Modification module involves quizzes in the lab that has users identify different types of man-made structures, as well as calculate specific conclusions based on collected data such as the hypotenuse of a triangle using geometry and measurements collected in the field. Additionally, the lab after completing the Plastic Pollution module teaches users how to observe certain qualities of samples collected in the field such as the different traits of soil observed under a microscope [12].

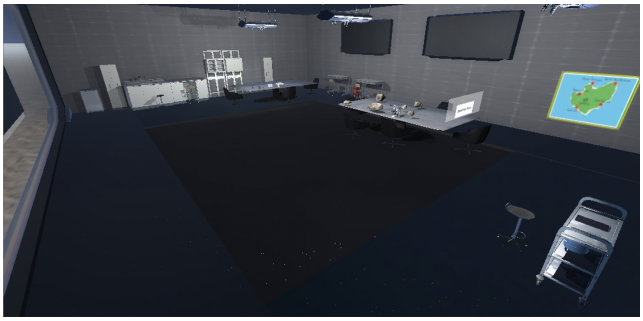

Fig. 5. The virtual lab where users will be educated on their selected module, test their samples, and/or answer questions.

IV. Evaluation

We enlisted 34 users to navigate our program through VR and complete a pre- and post-survey indicating their comfort levels, as well as a pre- and post-quiz to evaluate their learning outcome from the experience. Out of these users, 13 identified as female, 18 identified as male, and 3 preferred not to say. Most users were enrolled in college with 3 first-year students, 7 second-year, 9 third-year, 11 fourth-year, 1 fifth-year or higher, and 2 graduate students, 1 user selected other. When asked about ethnicity/racial profiles, 5 users identified as Black/African American (15%), 6 identified as Asian (17%), 2 identified as Hispanic/Latino (6%), 19 identified as White (56%), and 2 users preferred not to say (6%). Furthermore, 20 were Computer Science majors (59%), 5 were Environmental

TABLE I
SURVEY RESULTS ON TURTLE VR

Item		Disagree		Somewhat Disagree		Neutral		Somewhat Agree	Agree		N
I had a sense of being there.	0.00%	0	10.00%	3	10.00%	3	60.00%	18	20.00%	6	30
I felt that the virtual world surrounded me.	0.00%	0	3.23%	1	16.13%	5	54.84%	17	26.67%	8	31
I felt like I was just perceiving pictures.	6.45%	2	35.48%	11	12.90%	4	35.48%	11	9.68%	3	31
I did not feel present in the virtual space.	16.13%	5	54.84%	17	12.90%	4	12.90%	4	3.23%	1	31
I had a sense of acting in the virtual space	3.23%	1	6.45%	2	22.58%	7	45.16%	14	22.58%	7	31
I felt present in the virtual space.	0.00%	0	12.90%	4	9.68%	3	64.52%	20	12.90%	4	31
I was not aware of my real environment.	9.68%	3	32.26%	10	6.45%	2	32.26%	10	19.35%	6	31
I still paid attention to the real environment.	6.45%	2	9.68%	3	9.68%	3	48.39%	15	26.67%	8	31
I was completely captivated by the virtual world.	0.00%	0	13.33%	4	33.33%	10	40.00%	12	13.33%	4	30
I was aware of the real world surrounding me while navigating in the virtual world.	3.23%	1	16.13%	5	12.90%	4	41.94%	13	26.67%	8	31
The virtual world seemed real to me.	9.68%	3	19.35%	6	32.26%	10	32.26%	10	6.45%	2	31
My experience in the virtual environment seemed consistent with my real world experience.	9.68%	3	12.90%	4	29.90%	9	38.71%	12	9.68%	3	31
The virtual world seemed more realistic than the real world.	38.71%	12	38.71%	12	12.90%	4	6.45%	2	3.23%	1	31
I enjoyed this experience.	0.00%	0	3.23%	1	9.68%	3	32.26%	10	54.84%	17	31
I learned something from this experience.	0.00%	0	0.00%	0	9.68%	3	51.61%	16	38.71%	12	31
This experience makes me want to learn more about this topic.	0.00%	0	9.68%	1	22.58%	7	38.71%	12	35.48%	11	31

Science/Natural Resources majors (15%), 4 were Engineering majors (11%), and there was 1 person in each of the Biology, Humanities and Social Science, Business/Management, Visual and Performance Arts/Architecture and Design, and Math/Statistics majors (3% each). Additionally, 17 users identified themselves as STEM people, and 13 clarified that their parents and professors would identify them as STEM people.

User Experience: Most of the users who participated in this study reported positive feedback on the virtual environment in the post-survey provided after the experience. Users were prompted with questions about if they were immersed in the virtual environment, if they perceived the virtual world as real, or if they had a sense of acting in the virtual space. Approximately 80% of users agreed that the virtual world provided an authentic experience and offered sufficient learning opportunities, and roughly 87% expressed satisfaction with the experience, reported learning from it, and expressed an eagerness to explore the subject further. The User Experience graph indicates that a majority of users agreed with statements expressing a positive report of the learning environment provided by Turtle VR. Additionally, a majority of users disagreed with statements expressing negative feedback with the virtual world. Most users reported to have none of the common symptoms associated with being in the VR environment including general discomfort, nausea, and burping.

Learning Outcome: The user study provided students with a pre- and post-quiz to determine the learning benefits provided by Turtle VR. Prior to completing the plastic pollution module, users scored an average of 61.3% on the quiz, and an average of 75.1% after completing the module. There was one user who scored a 100% on the pre-quiz, meaning that they could not score any higher on the post-quiz. On average, there was about a 13.8% increase in score for 63% of users after completing the VR experience. Overall, the results from the pre- and post-quiz indicate that Turtle VR has the potential to provide students with sufficient tools to enhance their learning experience.

V. CONCLUSION AND FUTURE WORK

We propose a student-centered learning VR tool tailored for aspiring geological engineering students, providing safer, more cost-effective access to essential real-world, hands-on experiences. The goal for this VR learning environment is to enhance education and provide students with necessary experience that may be difficult to obtain using traditional teaching methods.

The user study results outlined in this paper indicate that students enjoyed the virtual reality experience, and motivated them to want to learn more about the material covered in Turtle VR. This not only potentially provides students with an adequate learning tool, but also minimizes the requirement for an instructor with sufficient knowledge on the subject to educate students. These results also express that most users did not experience the negative effects associated with the VR environment.

In the future, we plan to test Turtle 360, an interactive 360 video covering the same materials as Turtle VR, using both a VR headset and a desktop. Future work will also include expanding our user study to potentially prove Turtle VR is a sufficient learning alternative to actual field trips. We hope to use a control group that consists of students attending an actual field trip, and an experimental group consisting of students attending the virtual field trip through Turtle VR. The purpose of this study will be to prove Turtle VR's educational sufficiency when compared to an actual field trip, and determine if virtual reality can provide an exceptional alternative to hands-on learning experiences gained from field work. Ultimately, our goal is to use Turtle VR's foundation to also benefit other engineering education requiring field work, such as an aspiring mechanical engineer working on an engine, an environmental engineering student in a city learning about rural cost effective energy sources (wind turbines or solar power for example), or a biomedical engineering major

building and testing a prosthetic without ever leaving the classroom. Additionally, this framework can be utilized in other fields like archaeology, where expeditions may be too expensive or impractical depending on the area within the subject being explored, such as exploring an ancient pyramid or researching prehistoric animals.

ACKNOWLEDGEMENTS

This material is based in part upon work supported by: The National Science Foundation under grant number(s) NSF awards # 2142428, 2142360. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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