VIRTUAL REALITY STEM TRAILS: EXPLORING MATH TRAILS WITH STEM EDUCATION APPROACH IN A VIRTUAL WORLD

Adi Nur Cahyono
Universitas Negeri Semarang, Indonesia

Abstract. This study explores how STEM-based math trails may be conducted virtually. We used the STEM Education approach, math trails concept, and virtual reality technology to develop a town-based STEM learning environment. In this project, a virtual reality mobile app was produced that can be used with Cardboard VR. Teachers build virtual trails with mathematics tasks related to municipal landmarks. Students utilize a virtual reality program on their phones to explore the trail. They employ the mathematical modeling cycle to solve real-world STEM problems. These activities can be done anywhere, anytime using cutting-edge technology. Experiments and deployment in several contexts are needed.

Key words: Math trails, STEM education, virtual reality.

INTRODUCTION

Interdisciplinary STEM curriculum helps students shift from theoretical to practical learning (Bergsten & Frejd, 2019; Corlu et al., 2014; Holmlund et al., 2018; Just & Siller, 2022; Kertil & Gurel, 2016). Teachers that desire to embrace STEM education have several options accessible. When a country succeeds in STEM (science, technology, engineering, and math), its prospects of worldwide success and prosperity grow (STEM). These subjects must be taught to prepare pupils for society's present and future requirements. Math's practical applications may be more visible, but it's the foundation of STEM (Just & Siller, 2022).

The actual world provides STEM classrooms ideas. In many countries across the world, students may learn math while visiting historical and cultural sites. Based on errand data, pathways may be established between different task locations. They may pick a route with math diversions. The "math trail" is named appropriately (Shoaf et al., 2004). Dudley Blane and his crew proposed a math route across Melbourne. Once schools started using this grade in math, it gained popularity. Vancouver, Boston, Philadelphia, and San Francisco followed the pilot's success.

We may create a digital math trail using cutting-edge technology (Cahyono et al., 2020; Cahyono & Ludwig, 2019; Ludwig & Jesberg, 2015; Zender et al., 2020). In this study, we utilized VR to build new math trails. These panels are replacing conventional interactive displays due to their realistic 3D imagery (Xiong et al., 2021). VR users with the right eyewear and input devices may interact with computer-generated worlds. Virtual reality is a potential tool for effecting pedagogical modifications in the classroom (Wohlgenannt et al., 2020). This study's main question is: How STEM-based math trails may be conducted virtually?

Cahyono, A. N. (2023). Virtual Reality STEM Trails: Exploring Math Trails with STEM Education Approach in a Virtual World. In M. Ludwig, S. Barlovits, A. Caldeira, & A. Moura (Eds.), *Research On STEM Education in the Digital Age. Proceedings of the ROSEDA Conference* (pp. 85–90). WTM. https://doi.org/10.37626/GA9783959872522.0.10

METHODS

Exploratory research with junior high school teachers and students was done to find the solution. We developed a VR STEM Trails App and conduct some pilots of virtual reality STEM Trails activities. Researchers observed students as they worked in each pilot and interviewed them afterward to get their feedback. Worksheets were reviewed, and comments were offered. Student responses were collected in a survey after they had finished the activities.

RESULTS

In this study, a model of the learning environment was designed by constructing math trails using a STEM approach in a digital world that was equipped with virtual reality technology. The application was designed to work on mobile devices accompanied with Cardboard VR (Figure 1). This application offers a learning environment in a virtual town with some landmarks that are most well-known in Indonesia. The math trail is comprised of the total of the outcomes of the many mathematical activities that are tied to the various landmarks along the path. Utilization of aspects of science, technology, engineering, and mathematics are required throughout the process of developing tasks. By using this application in combination with Cardboard VR, users can work together on their virtual mathematical trails.

Figure 1: The app and devices used in this activity.

Teachers may explore the virtual town with the help of Cardboard VR by utilizing the app to do so. They can then use the app to develop math trails projects related to the locations they

find while doing so. The planning procedure for the task considers scientific, technological, engineering, and mathematical fields. The teacher has also completed their part of the project by offering the user assistance in finding a solution to the problem that they are now facing. Other methods have also been provided as part of the work that has been produced, and they form an essential part of this effort. After the task has been defined, the association uses group discussions to assess it. These discussions take place inside the association. Every teacher comes up with a task on their own, and then all those separate tasks, together with the ones that were produced by the other teachers, are put together to make a trail. There are numerous tasks that are developed; nevertheless, according to the results of the discussion, the ideal number of tasks that should be included in a trail is between four and five. This is the case even though there are many tasks that are generated. Figure 2 shows the activities conducted by the teachers.

Figure 2: Teachers' activities.

Student collaborates on projects with other classmates in groups of two to three students. Every group receives its own set of apps, Cardboard VR, and student worksheets. They collaborate with one another to solve mathematical problems while wearing Cardboard VR headsets and exploring virtual town. Students follow location markers that are posted at the curb at each junction or use accessible routes to help them trace math trails and find landmarks that are connected to topics they are working on in math class. This helps students discover landmarks that are connected to topics they are working on in math class. After doing a search for a location, it normally takes around a minute to find what you're looking for. After the students have determined the correct location, the following step calls

for them to read the job description that is written on the board that is situated all around the landmark. Figure 3 shows the activities conducted by the students.

Figure 3: Students' activities.

When the user has discovered the position of the landmark that it is meant to send them to, a board will emerge that offers information on the action that has to be carried out at that spot. Users first collect data that has been available at that location to complete the activity, and then they solve the task that has been posed to them by following a mathematical modeling cycle. After leaving Cardboard VR, the user will start using the worksheets that have been provided as a supplement to this app.

Utilizing the worksheets, the user's objective is to not only record the data and information that was obtained but also the solutions to the problems that were encountered at the task site. They are going to make use of Cardboard VR again to proceed with their journey to the subsequent spot where they will complete a work if they have previously completed a task in the present location. These activities are shown in Figure 4.

As part of this implementation, students will work on an application for a length of time that is roughly equivalent to three minutes. They next put away the tool and conclude the project by having a conversation with their group and recording their work on a worksheet. After that, the tool is put away. They resumed employing the tool and continued their journey to examine the trail and discover answers to new challenges that they encountered along the way in other regions once they had successfully completed the mission.

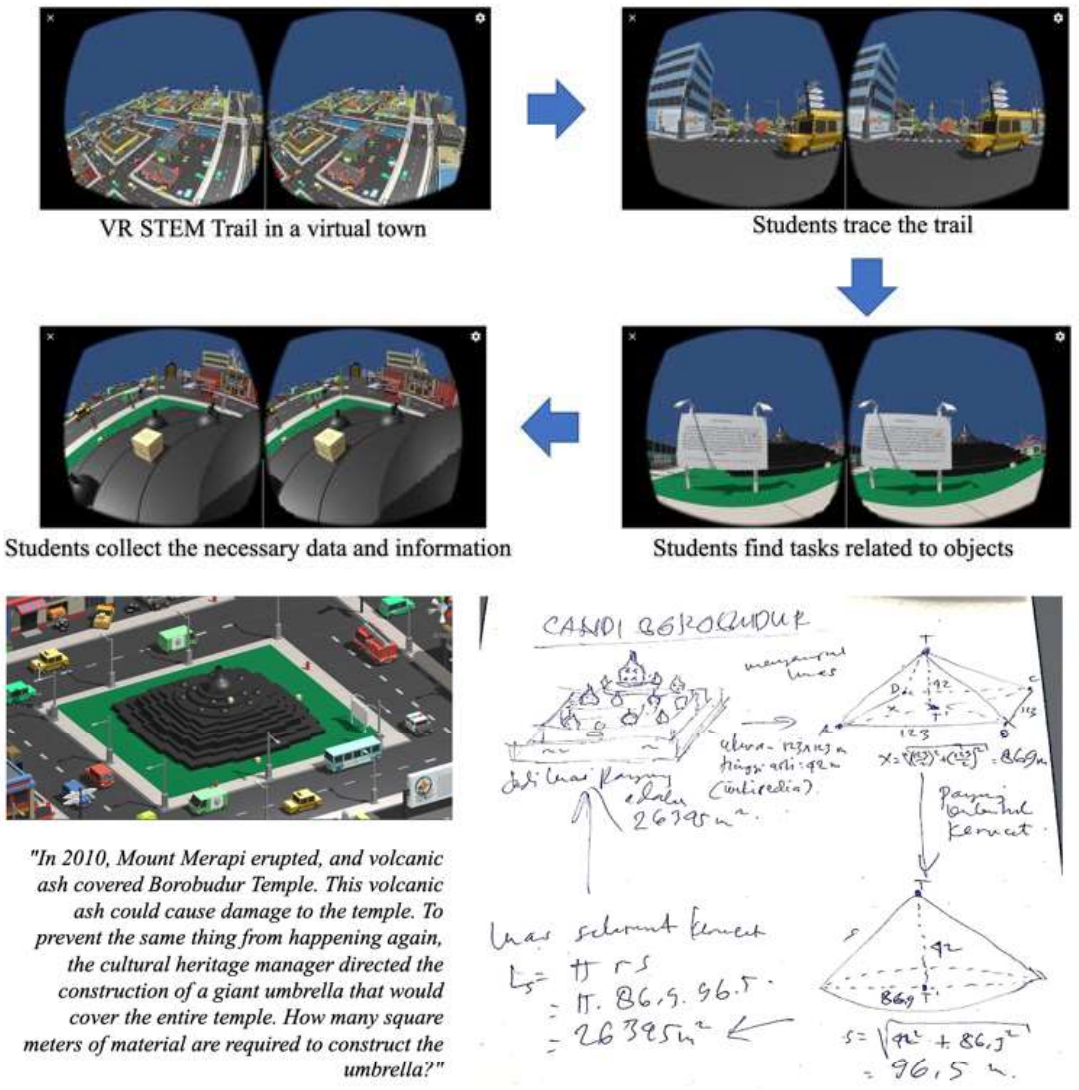

Figure 4: Learning activities.

In this activity, students learn about mathematics about surface area which is integrated with science related to the impact of volcanic ash from the eruption of Mount Merapi on buildings. This activity is also integrated with engineering by teaching students in designing building construction. The use of technology in this activity has been able to facilitate the integration of fields in STEM.

CONCLUSION

In this study, a VR app for mobile phones was developed that works with VR Cardboard headset. Plans for teaching and learning mathematics were also produced as part of this study. Teachers may create virtual reality environments with mathematical challenges based on landmarks in a made-up town. Like conventional math trails, students use a virtual reality app on their mobile devices to follow the path mapped out by the teacher. They run across STEM (science, technology, engineering, and mathematics) tasks along the trail, which they solve by using the mathematical modeling cycle. In a pilot program, students' mathematical

modeling abilities for addressing real-world issues were enriched, and they participated more actively in mathematics-related activities. By using the advancements in technology, it can be done anytime and wherever. Large-scale trials are required, as are widespread implementations of the results.

References

Bergsten, C., & Frejd, P. (2019). Preparing pre-service mathematics teachers for STEM education: an analysis of lesson proposals. *ZDM–Mathematics Education, 51*(6), 941–953.

Cahyono, A. N., & Ludwig, M. (2019). Teaching and Learning Mathematics around the City Supported by the Use of Digital Technology. *EURASIA Journal of Mathematics, Science and Technology Education, 15*(1), em1654.

Cahyono, A. N., Sukestiyarno, Y. L., Asikin, M., Miftahudin, M., Ahsan, M. G. K., & Ludwig, M. (2020). Learning Mathematical Modelling with Augmented Reality Mobile Math Trails Program: How Can It Work? *Journal on Mathematics Education, 11*(2), 181–192.

Corlu, M. S., Capraro, R. M., & Capraro, M. M. (2014). Introducing STEM education: Implications for educating our teachers for the age of innovation. *Education and Science, 39*(171), 74–85.

Gao, X., Li, P., Shen, J., & Sun, H. (2020). Reviewing assessment of student learning in interdisciplinary STEM education. *International Journal of STEM Education*, *7*(1), 1–14.

Just, J., & Siller, H. S. (2022). The Role of Mathematics in STEM Secondary Classrooms: A Systematic Literature Review. *Education Sciences, 12*(9), 629.

Kertil, M., & Gurel, C. (2016). Mathematical Modeling: A Bridge to STEM Education. *International Journal of Education in mathematics, science and Technology*, *4*(1), 44–55.

Ludwig, M., & Jesberg, J. (2015). Using Mobile Technology to Provide Outdoor Modelling Tasks - The MathCityMap-Project. In H. Uzunboylu (Ed.), *Procedia - Social and Behavioral Sciences* (pp. 2776–2781). ScienceDirect.

Shoaf, M. M., Pollak, H., & Schneider, J. (2004). Math Trails. COMAP.

Wohlgenannt, I., Simons, A., & Stieglitz, S. (2020). Virtual Reality. *Business & Information Systems Engineering, 62*(5), 455–461.

Xiong, J., Hsiang, E. L., He, Z., Zhan, T., & Wu, S. T. (2021). Augmented reality and virtual reality displays: emerging technologies and future perspectives. *Light: Science and Applications, 10*(1), 1–30.

Zender, J., Gurjanow, I., Cahyono, A. N., & Ludwig, M. (2020). New studies in mathematics trails. *International Journal of Studies in Education and Science, 1*(1), 1–14