Integrating Virtual Reality Tools into Secondary School Classrooms to Address Gender Gap in STEM Education: An Action Plan

Yixuan Chi

Department of Digital Learning, Monash University, Melbourne, Australia

Abstract: This action plan addresses the gender gap in STEM education by integrating Virtual Reality (VR) tools into secondary school classrooms. Despite various strategies to increase female participation in STEM fields, women remain underrepresented in these areas. The action plan proposes the use of immersive and interactive VR experiences to create more engaging learning environments that may attract a diverse student body, particularly female students. By leveraging the potential of VR to simulate science experiments and other STEM-related activities, this project aims to enhance students' interest and confidence in STEM subjects. A pilot will be conducted in a secondary school, with approximately 50-100 students and a dedicated STEM teaching team. Key strategies include virtual reality technology training for teachers, the design of inclusive STEM curricula, and continuous evaluation through both formative and summative assessments. The expected outcome is that female students will show increased willingness to pursue further study and careers in STEM fields, contributing to long-term reductions in the gender gap in STEM education.

Keywords: Virtual Reality; STEM Education; Gender Gap.

1. Goal

To address gender gap in STEM education and increase its appeal to a diverse student body, immersive and interactive learning experiences are created by introducing virtual reality tools into secondary school classroom.

2. Rationale

In traditional secondary school STEM education, there exists the notion that male students outperform female students in the fields of science, technology, engineering, and mathematics (Bahar, 2021 [1]; Halpern, 2007 [2]). Due to the influence of these preconceived notions, female students lack the confidence to choose to study these subjects during their secondary education (Dweck, 2007 [3]). The study by Merayo and Ayuso (2023) [4] also mentions that the lower proportion of women in STEM jobs leads to significant annual productivity losses in the European economy. Therefore, the European Union has actively launched various strategies to increase female student participation in the STEM industry and promote STEM skills and education. The secondary school stage is a critical period for students to lay the foundation in various subjects and is an important phase that connects to their future career development. Hence, addressing the gender gap in secondary school STEM education can significantly alleviate the underrepresentation of women in STEM fields.

Integrating virtual reality (VR) tools into secondary education is a potent strategy for addressing gender gaps in STEM fields. Research by Makransky et al. (2020) [5] has found that using immersive virtual reality tools to simulate science experiments for secondary school students can effectively stimulate their interest in science courses. Furthermore, the study also found that the use of immersive virtual reality tools increased the willingness of female learners to study science courses, with this increased willingness to learn being even more pronounced among female learners than male learners. This result demonstrates the significant potential of virtual reality tools in balancing gender differences in STEM fields (Makransky et al., 2020) [5].

Therefore, I propose launching an action plan aimed at assisting secondary school STEM educators in utilizing virtual reality tools in their classrooms to increase the attraction of STEM subjects to a diverse student population, especially to increase the participation of female learners, by creating immersive and interactive learning experiences. My intended outcome for this action plan is that by using virtual reality tools in secondary school STEM education can effectively address gender gaps in STEM education.

3. Strategies

This action plan will be piloted in one secondary school. If the pilot results align with the intended outcomes, the action plan will be implemented in more secondary school STEM education programs.

3.1. Participant Explanatory Statement and Consent Form

Participant explanatory statement is typically a document used in research to inform participants about the nature, purpose, and impact of the study they are invited to join. It is a crucial part of research ethics to ensure that participants are fully informed before consenting to participate. Therefore, the first strategy of this action plan pilot is for the project team to distribute participant explanatory statements to all students and STEM teachers at the pilot secondary school. This will ensure they are fully informed about the goal of the action plan, the research objectives, project procedures, and information about the project team.

Following this, consent forms for participating in the pilot project will be distributed and signed by the students and faculty who have thoroughly understood the project details and agreed to participate in the pilot. Students and faculty participating in this action plan will be informed in person that their personal privacy data will be protected and used only for this action plan pilot.

3.2. Forming Pilot Classes and STEM Teaching Teams

By signing and collecting consent forms, students who are willing to participate in the pilot will be selected to form a class. The action plan aims to recruit approximately fifty to one hundred students for the pilot, with fifty students per class, which can be divided into two classes for the pilot. For the STEM academic staff willing to participate in the pilot, a new teaching team will be formed, and they will undergo subsequent VR technology training and virtual reality STEM course content design discussion meetings. The total number of teachers expected to be recruited for this action plan is about six to eight people. The STEM teaching team will work closely with the action plan project team, and this action plan also requires the inclusion of one instructional designer (ID) and one VR technology operator.

3.3. Virtual Reality Technology Training

The STEM teaching team will undergo virtual reality technology tool operation training in the classroom under the guidance of VR technology operators. Because, considering the effort expectancy factor (EE) in the Unified Theory of Acceptance and Use of Technology (UTAUT) framework, teachers' familiarity with technology (TK) will affect their perceived ease of use of the technology (Venkatesh et al., 2003) [6]. Thus, enhancing teachers' knowledge and operational skills in VR technology can reduce their expected difficulty in using VR technology tools and encourage them to choose to use VR technology in their STEM teaching. Therefore, it is essential to develop their technological knowledge (TK) under the premise that the STEM teaching team possesses pedagogical knowledge (PK) and content knowledge (CK) (Mishra & Koehler, 2006) [7]. The VR technology training in this action plan is expected to take two days, during which staff will undergo systematic training and practical hands-on learning and develop experience with the technology tools.

3.4. Inclusive Curriculum Design

After the training concludes, the STEM teaching team will collaborate with instructional designers to jointly design more attractive and inclusive STEM teaching content, which can be effectively integrated with VR technology tools. Instructional designers will incorporate more inclusive elements when designing VR classrooms. For example, when students use VR technology tools for STEM course knowledge acquisition, they can freely choose interactive VR teacher avatars. This strategy is crucial for determining whether the entire action plan can meet the expected outcomes. According to Merayo and Ayuso's (2023) [4] research, the presence of female STEM role models in schools increases and inspires female learners' interest in STEM subjects. Therefore, when female students can choose from more outstanding female scholars in the STEM field as VR teacher avatars in their learning, they may be able to experiment and explore in a safe and pressure-free environment, thus enhancing their confidence and practical skills.

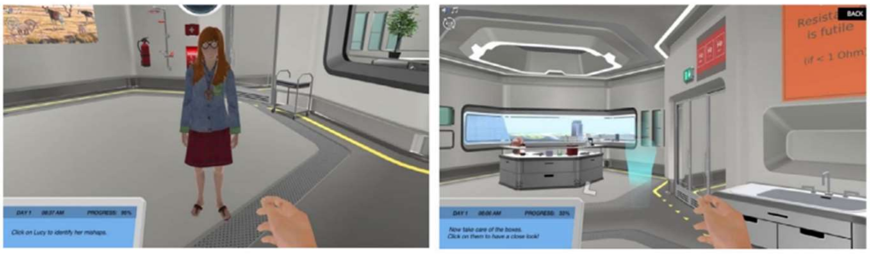

Figure 1. Instructional designers will incorporate more inclusive elements when designing VR classrooms
Note. Images are only for reference and illustration purposes.

3.5. Evaluation

After completing the first four strategies, the formal pilot phase can commence. Students participating in the action plan will engage in self-exploration and learning of STEM course content using VR tools under the guidance and supervision of STEM teachers and VR technology operators. After each learning session, students are required to promptly provide feedback on their learning experience to the STEM teaching team and, if necessary, suggest improvements. Evaluation will be integrated throughout the entire process of the action plan, aiming to better achieve its goals and assist in realizing the expected outcomes.

4. Resources

This action plan may require the following resources, which I will categorize and elaborate on separately as human resources, financial resources, and physical resources.

The following table provides a brief summary:

Table 1. The resources for this action plan will be accessed and allocated as follows

Human resources	➢ Project team - Project team officer - Project team manager - VR technology operators - Instructional designers ➢ STEM academic staff members ➢ Students
Financial resources	➢ Costs for training STEM academic staff in VR technology (Strategy 3) ➢ Renting or purchasing VR tools ➢ Salaries of the project team ➢ Salaries of the instructional designer ➢ Salaries of the VR technology operator
Physical resources	➢ Meeting rooms ➢ Classrooms needed for the pilot classes (one or two) ➢ Project team office space

The resources for this action plan will be accessed and allocated as follows:

4.1. Human Resources:

The officer and manager roles within the project team can be filled by school administrators or recruited and employed independently by the school. Additionally, the school will need to hire an additional VR technology operator and instructional designer for the project team.

Project Officer: Executes administrative tasks, collects and analyzes data.

Project Manager: Ensures the implementation of the action plan, addresses other team challenges, and manages the evaluation process.

VR Technology Operator: Responsible for training the teaching team in the project and assisting teachers in practical operations.

Instructional Designer: Collaborates with STEM academic staff to develop teaching content.

4.2. Financial Resources:

Implementing this pilot action plan requires the school to allocate a sufficient budget. The budget will be used to cover the costs of training STEM teachers in VR technology, renting or purchasing VR tools, salaries for the project team, and salaries for instructional designers. The salary for the VR technology operator may largely be included in the training costs, but this will still need to be determined based on specific circumstances.

4.3. Physical Resources:

The school can allocate one to two unused classroom seats for the classrooms needed for the pilot classes, while meeting rooms and the project team's workspace can be substituted with the school's conference rooms or teachers' offices.

5. Outcomes

I will develop and review this action plan through both formative assessment and summative evaluation. Formative assessment is conducted during the learning process to monitor students' progress and provide continuous feedback for teachers to improve teaching methods and for students to enhance learning strategies (Zobel, 2013) [8]. Formative assessment will be integrated throughout the entire action plan, with the following specific assessment components:

Instructional designers and the teaching team can design brief quizzes about STEM knowledge for students to answer during interactions between students and VR teachers. After each learning session, students can take a short test. Student academic performance data will be used to assess the extent of students' absorption of STEM knowledge.

After each VR session, students will be given a questionnaire to understand areas in which they believe adjustments are required within the course. Once the feedback is collected and provided to the teaching team, they can discuss it in meetings with the project team and instructional designers to make necessary adjustments to the teaching content.

Unlike formative assessment, summative assessment primarily focuses on the final results and performance of learning, used to determine whether students have achieved the expected learning objectives (Zobel, 2013) [8]. The following are specific assessment components for this action plan:

Before the start of the action plan pilot, the project team needs to administer a survey to the students participating in the pilot to determine their willingness to pursue further study in STEM courses or careers in STEM industries. The same survey will be administered again after the conclusion of the action plan pilot. Evaluation of whether this action plan meets the expected goals and outcomes will be based on the data revealed by the survey responses. If female students participating in the pilot express increased willingness to continue studying STEM courses and pursue future careers in STEM-related fields, it will be considered as meeting the expected objectives.

6. Reflection

I believe that to ensure the sustainability of this action plan, the following measures may be taken: provide ongoing teacher training to ensure they are proficient in VR technology and up-to-date with the latest advancements. Establish a student feedback mechanism to improve teaching methods, design diverse courses to meet the interests and needs of different students, maintain and update equipment to ensure continuous teaching, collaborate with tech companies and research institutions to obtain the latest resources and support, encourage community and parent involvement to gain broader support, and regularly evaluate project outcomes and make necessary adjustments.

However, I believe that the biggest challenge in this action plan might be the cost of VR tools. Since VR tools are relatively expensive, they may not be suitable for all secondary schools, and the situation of secondary schools varies from country to country. In Australia, for instance, private schools may have more funding than public schools, making them more suitable for the implementation of this action plan. Moreover, in some remote schools, STEM teaching staff might face other technical issues, such as the use of multimedia. Therefore, incorporating virtual technology tools into their teaching remains a challenge.

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