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Empowering Teachers with VR Technology for Immersive Science Learning Experiences

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ABSTRACT

Background: The study explores insights from participants' discussions on the utilization of Virtual Reality (VR) technology in education and proposes recommendations to improve teacher competence in this domain.
Contribution: The aim of this study was to identify training needs and educators' preferences in effectively integrating VR tools into their teaching practices.

Method: This study used a qualitative approach with interviews and FGDs involving educators experienced in VR technology. Thematic analysis identified key themes on the benefits, challenges, and training needs for effectively integrating VR into teaching practices..
Results: Thematic analysis revealed strong interest in using VR for immersive learning, but highlighted the need for additional training to overcome technical challenges, develop pedagogical strategies, and align VR use with curriculum requirements.
Conclusion: Based on the findings, recommendations include comprehensive VR training, hands-on practice, showcasing diverse applications, strategies for student engagement, and ongoing professional development. These steps will enhance educators' ability to effectively integrate VR into teaching, fostering innovative learning environments.

1. Introduction

Virtual reality (VR) technology has the potential to revolutionize the way we learn and experience the world around us. In recent years, educators have explored the use of VR in the

classroom to create immersive learning experiences that engage students and enhance their understanding of complex concepts. A recent study aimed to investigate the potential of VR technology in increasing environmental awareness among primary school students, highlighting the opportunities and challenges associated with this innovative approach [1], [2].

The use of VR technology in the classroom offers several important advantages. First, it allows students to experience environments and concepts that may be difficult or impossible to replicate in a traditional classroom setting, creating a more engaging and immersive learning experience that grabs students' attention and motivates them to learn [3], [4]. Secondly, VR technology can facilitate simulations that allow students to experiment with complex ideas and concepts in a safe and controlled environment, improving their understanding and retention of material [5], [6].

Despite these benefits, the implementation of VR technology in schools is not without its challenges. One significant concern is the cost of VR equipment, which can be prohibitive for many schools. In addition, there are potential problems related to distraction or disorientation when using VR, which can negatively impact learning outcomes [7]. To overcome these barriers, teachers need to acquire the necessary skills not only to operate VR technology but also to integrate it effectively into their teaching strategies and promote learning objectives [8]–[11].

While existing research underscores the potential of VR in education, there are important gaps in understanding how best to support teachers in adopting and making the most of this technology [12]. Ensuring that teachers are well equipped and confident in using VR is critical to maximizing its benefits in the classroom [13], [14]. This article aims to address this gap by exploring how teacher community engagement can facilitate the effective application of VR technology in educational settings.

Focusing on middle school science teachers is justified for several reasons. Middle school is a critical period for developing students' interest in science, and effective teaching during these years can have a lasting impact on students' future academic choices and career paths [15]. VR can make abstract scientific concepts more tangible and accessible, thereby fostering deeper understanding and engagement [16], [17]. Additionally, science education often involves experiments and demonstrations that can be logistically challenging or even impossible to conduct in a traditional classroom setting. VR can overcome these limitations by providing virtual simulations that replicate real-life experiments and phenomena [16], [17].

This situation is also evident among physics teachers in Yogyakarta, as reflected in statements from several teachers at the Physics Teachers Association. Given the current skill

limitations of teachers regarding this aspect, training in the use and application of VR in teaching is essential. This training aims to:

1. Improve teachers' skills in using VR.
2. Improve teachers' ability to design VR-assisted learning strategies.
3. Identify teacher needs for personal development.

By addressing these objectives, this study contributes to the broader context of educational technology trends and provides practical guidance for implementing VR-based teaching strategies in science education.

Research Questions:

1. What is the purpose of the training program aimed at enhancing teachers' proficiency in technology?
2. Why is it important for teachers to participate in VR-related professional development sessions?
3. What is one of the key goals of assessing teachers' experiences and challenges with VR technology?

2. Method

2.1. Participants

Five high school physics teachers from five different schools participated in the study. All participants were men and women between the ages of 30 and 45.

Gender

No.	Initial	Affiliation	Gender
1	PJL	MTs Negeri 3 Bantul	Female
2	TRN	MTs Negeri 3 Bantul	Female
3	RRD	MTs Muhammadiyah Bantul	Female
4	SHM	MTs Negeri 3 Bantul	Male
5	BAH	MTs Negeri 8 Bantul	Male

2.2. Characteristics of VR

The study leveraged VR technology to create immersive learning experiences focused on animals in their natural habitats. This VR experience allows students to explore different animal environments and engage in virtual field trips to wildlife sanctuaries. Its main goal is to promote environmental awareness and inspire future generations to become responsible custodians of the planet.

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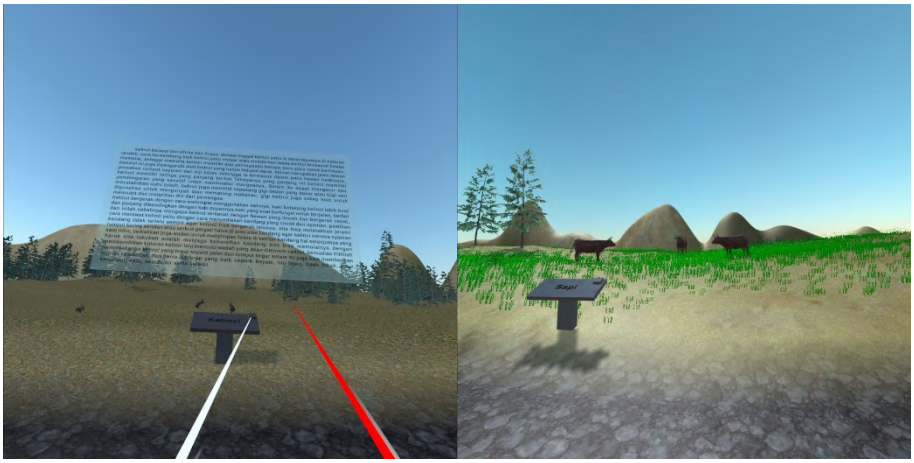

Figure 1. Some examples of VR situations

2.3. Training Stages

1. Introduction to VR and Operations: The instructor introduces VR technology and explains its components and functions. The instructor demonstrates the use of these components and specifically describes and demonstrates the application of Zoo-VR, which will be used in training.
2. Exploration with VR: Participants explore VR technology firsthand. They tried out VR headsets, experimented with all the buttons and menus, experienced a virtual journey at the zoo, and interacted with various features in the virtual app.
3. Group Discussions: Participants engage in discussions to identify subjects suitable for VR integration, set learning goals achievable through VR, identify additional teaching materials needed, and design appropriate learning strategies.

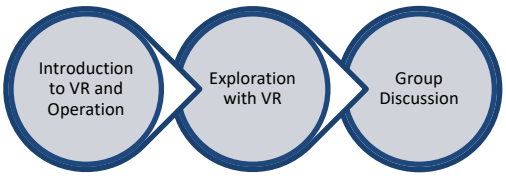

Figure 2. Training Phase

2.4. Success Measurement

The success of the training is evaluated based on three aspects. The first is Improving Teachers' Skills in Using VR: This is assessed through participants' observation as they operate VR equipment. The second is Improving Teachers' Ability to Design VR-Assisted Learning Strategies: This is measured by evaluating the lesson plans created by the participants. Third is

Improving Teachers' Ability to Develop VR-assisted learning performance: This is assessed through analysis of learning competencies achieved from VR-based teaching sessions.

2.5. Data Analysis

Thematic analysis was conducted following a structured process: familiarization with the data through transcription and repeated reading, generation of initial codes from significant data segments, organization of these codes into potential themes, and refinement through a two-level review process [18]–[20]. Themes were then clearly defined, named, and integrated into a cohesive narrative. This systematic approach ensured a thorough exploration of the data, revealing key insights into middle school science teachers' experiences with VR technology in education.

3. Results and Discussion

3.1. Improve Teachers' Skills in Using VR

This was assessed through participants' observations as they operated VR equipment. This was assessed through participants' observations as they operated VR equipment. Observers focused on several key indicators, such as participants' ability to navigate VR interfaces correctly and efficiently, troubleshoot any technical issues, and effectively use VR tools to explore virtual environments. In addition, observers noted how comfortable and confident the participants appeared when using the technology, as well as their ability to follow instructions and complete specific tasks in VR applications. Detailed notes and assessments are recorded to evaluate each participant's proficiency and improvement during the training session.

Figure 3. Participants experience VR

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3.2. Improving Teachers' Ability to Design VR-Assisted Learning Strategies

This is measured by evaluating the learning plans created by the participants. This is measured by evaluating the learning plans created by the participants. Assessment is focused on several criteria, including the coherence and creativity of lesson plans, the integration of VR technology into the curriculum, and the alignment of learning objectives with VR activities. Evaluators are looking for evidence that teachers can effectively incorporate VR to improve student engagement and understanding of complex concepts. In addition, the plan is reviewed for its practicality, clarity of instruction provided to students, and inclusion of assessment methods to measure student outcomes. Feedback is provided to each participant to help refine and improve their VR-assisted learning strategies.

a. *RRD: The interactivity of VR tools is higher compared to traditional teaching methods because with VR tools it seems to be the experimental work.* This VR tool can be integrated into the learning curriculum in various subjects. [The interactivity of VR tools is higher compared to traditional teaching methods because VR tools simulate live experiments. These VR tools can be integrated into learning curricula across a wide range of subjects.]
b. *TRN: This VR experience exceeded my expectations. VR tools are integrated into the learning curriculum to promote more effective learning. Suitable science materials, for example, are animal classification or pollution.* [TRN: The VR experience exceeded my expectations. VR tools are integrated into the learning curriculum to promote more effective learning. Appropriate science materials cover topics such as animal classification or pollution.]
c. *STC: VR can and does support the learning curriculum in any learning subject. In my opinion, VR is suitable for any material, especially global warming material and other materials from biology and social studies subjects*. [VR can greatly support the learning curriculum for any subject. In my opinion, VR is suitable for any material, especially topics on global warming and other subjects in biology and social studies.

From the respondents' statements, it can be concluded that VR tools offer a much higher level of interactivity compared to traditional teaching methods, effectively simulating live experiments. For example, advanced VR systems use technology to stimulate various senses, such as smell, hearing, and touch, in addition to visual and auditory stimuli. This makes the virtual environment more realistic and engaging [21], thus improving learning outcomes. Other study is produced fun virtual reality has the potential to increase students' understanding of different areas of education and improve their understanding of complex spatial layouts when compared to traditional learning [22]. Respondents believe that VR can be seamlessly integrated into various subjects in the curriculum. They noted that VR exceeded their expectations, increasing the effectiveness of learning, especially in science subjects such as animal classification and pollution. In addition, respondents highlighted that VR strongly supports any

curriculum, making it suitable for topics such as global warming in biology and social studies, demonstrating its versatility and wide applicability across a wide range of subjects.
It also concluded that this training has the potential to improve teachers' ability to design VR-assisted learning strategies. The respondents acknowledged that VR tools offer higher interactivity and can be integrated into a variety of subjects, suggesting that they see the value and potential of these tools in an educational context. Therefore, the training they attended seems to have successfully helped teachers understand how to utilize VR technology to make learning more effective and engaging.

3.3. Identify teacher needs for personal development

This training will have a significant impact on each teacher's professional development needs by equipping them with the skills and knowledge to effectively integrate VR tools into their teaching strategies. By participating in these trainings, teachers will enhance their ability to create engaging and interactive learning experiences, which can lead to a more effective and dynamic classroom environment. In addition, the training will help teachers stay abreast of technological advances in education, fostering continuous growth and improvement in their professional practice.

> SHN: *I think I need additional training to optimally use this CR. This VR can be an alternative to other learning media. In addition, it needs a lot of programs for some learning materials as an obstacle. This tool will give a new experience for sipa who use. Motivate to keep learning.* [I feel that I need additional training to use this VR tool optimally. VR can serve as an alternative to other learning media. In addition, various programs are required for some learning materials, which poses a challenge. This tool will provide a new experience for anyone who uses it and will motivate continuous learning. [
> BAH: *The use of VR tools can be used to obtain learning experiences that can be written, developed and published. I recommend VR tools because there are many creative ideas that can be developed to facilitate the learning process, but for that I still need additional training.* [The use of VR tools can be used to obtain learning experiences that can be documented, developed, and published. I recommend VR tools because they generate a lot of creative ideas that can be developed to facilitate the learning process. However, I still need additional training for this purpose.]
> TRN: *Need additional training. Including how learning can increase student interest in learning and ovittation to study hard.* [Additional training is needed, including how to increase students' interest in learning and motivate them to study diligently.

The statement highlighted the need for additional training for teachers to use VR tools effectively in the classroom. SHN emphasizes that while VR can be an alternative learning

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medium and offer unique and motivating experiences, VR requires more programming for specific materials. BAH noted that VR can generate creative ideas and enhance learning experiences that can be documented and shared, but also underscored the need for further training. TRN emphasizes the importance of training to increase students' interest and motivation to learn. Overall, this statement implies that to fully harness VR's potential in education, comprehensive professional development is essential for teachers [23].

It concludes that the participants need further training to improve their competence. The statements from SHN, BAH, and TRN collectively point out that while participants recognized the significant potential of VR tools to enhance learning experiences and generate creative teaching ideas, they also recognized gaps in their current ability to use these tools effectively. SHN points to the need for more additional programs and training to fully utilize VR capabilities. BAH stresses that further training is needed to develop and document these new learning experiences. TRN underscores the importance of training in increasing student engagement and motivation. Thus, the overall implication is that comprehensive and ongoing professional development is essential for teachers to maximize the educational benefits of VR technology.

The successful implementation of the empowerment training programme for teachers in Yogyakarta highlights several important implications for educational practice and policy. First, the programme demonstrates the potential of VR technology to enhance teaching and learning by providing immersive and engaging experiences that can deepen students' understanding of complex concepts. By equipping teachers with the necessary skills and confidence to integrate VR into their classrooms, the programme sets a precedent for similar initiatives in other regions and subject areas. The emphasis on practical applications and strategic planning ensures that teachers can effectively incorporate VR into their existing curricula, potentially transforming traditional teaching methods [24], [25]. Policymakers and educational leaders should consider investing in continuous professional development and support for teachers to sustain and expand the benefits of VR technology in education [26].

Despite the positive outcomes, this study has several limitations that should be addressed in future research. First, the study was conducted in a specific geographical location (Yogyakarta) and focused on a particular group of teachers, which may limit the generalizability of the findings to other regions or subject areas. Second, the evaluation of the programme's effectiveness relied on self-reported data from participants, which may be subject to bias. Future studies should include more objective measures of teacher performance and student outcomes to validate the findings. The long-term impact of the training programme on teaching practices and student learning remains unclear, necessitating further research to assess the sustainability of the improvements observed [26]. Finally, while the programme addressed initial skills gaps, ongoing challenges related to the cost and maintenance of VR equipment, as well as the need

for continuous technical support, should be considered in the development of future training initiatives.

3.4. Recommendations for Further Programs

Based on the discussions given by the participants, several recommendations can be made for advanced training programs. First, the program should focus on addressing specific needs identified by participants, such as providing comprehensive training on the effective use of VR tools and developing creative teaching strategies tailored to various subjects and learning materials. In addition, the program should offer hands-on practice sessions and demonstrations to enhance participants' practical skills and confidence in utilizing VR technology in the classroom. Furthermore, follow-up training programs should incorporate sessions dedicated to exploring various VR applications and resources relevant to various educational contexts. This can include displaying examples of successful VR-assisted learning experiences and guiding how to adapt and apply this approach in participants' teaching environments. In addition, given the participants' interest in increasing student engagement and motivation, the program should include modules on utilizing VR to create immersive and interactive learning experiences that captivate students' interest and encourage active participation. Strategies for integrating VR into lesson plans and curriculum frameworks should also be emphasized to ensure alignment with educational goals and standards. Lastly, follow-up training programs should be designed as ongoing professional development initiatives, offering opportunities for continuous learning and support beyond the initial session. This can involve establishing communities of practice where participants can share experiences, exchange ideas, and collaborate on innovative VR projects. Regular follow-up sessions, online resources, and mentoring opportunities can further sustain participants' growth and development in harnessing the potential of VR technology for education.

4. Conclusion

The empowerment training program for teachers in Yogyakarta has succeeded in improving their ability to utilize VR technology in their classrooms. Participants demonstrated significant improvements in operating VR equipment, designing VR-assisted learning strategies, and developing effective VR-based learning performance. Live training and collaborative discussions allow teachers to integrate VR into their teaching practices, creating a more engaging and immersive learning experience for students. By focusing on practical applications and strategic planning, the program addresses initial skills gaps and gives teachers the confidence and competence to use VR as a powerful educational tool. The positive results observed in student engagement and understanding underscore the potential of VR technology

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to revolutionize traditional teaching methods. Continuous support and further training will ensure that this progress is maintained and expanded, ultimately fostering a more innovative and effective educational environment in Yogyakarta.

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