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Using Virtual Reality and Augmented Reality to Learning Mathematics

Julia Nurlita[1*], Salwa Sabria Ramadhani[2], Wahyunengsih[3]
[1-3]Universitas Islam Negeri Syarif Hidayatullah Jakarta, Indonesia
julia.nurlita24@mhs.uinjkt.ac.id[1*] , salwa.sabria24@mhs.uinjkt.ac.id[2]

Korespondensi penulis: julia.nurlita24@mhs.uinjkt.ac.id

Abstract: The purpose of this study was to develop and test a mathematics learning tool using Virtual Reality (VR) technology on the Android platform. The material focused on is flat-sided spatial objects for junior high school students. The development stages were carried out through various steps, from planning to testing on students. The findings showed that the media was considered appropriate by experts, easily accessible to students, and contributed to improving learning outcomes. In addition, students appeared more enthusiastic and excited during the learning process. A review of two other articles confirmed that VR and AR-based media were able to improve understanding and make learning more enjoyable. This tool could be an interesting alternative for teaching mathematics.

Keywords: *Virtual Reality, Augmented Reality, Mathematics Learning, Spatial Objects, Learning Tools, Educational Technology*

1. INTRODUCTION

Virtual Reality is a technology for interacting with three-dimensional (3D) settings that are as close to the real world as feasible. A revolutionary technical development, virtual reality creates artificial three-dimensional (3D) settings that let users interact immersively and mimic real-world situations (Ganason, 2024). Wu confirms that virtual Reality is a digital methodology that reconstructs sensory experiences through equipment such as head-mounted displays and controllers, thereby facilitating natural locomotion in a virtual environment, in addition to augmenting understanding, modulating behavior, and enhancing perspectives on health through immersive encounters and instant feedback (Wu, 2024).

Augmented Reality (AR) technology inserts 2D or 3D digital elements into a real environment and shows them live at the same time. It turns virtual things into objects that look there (Sukirman, 2023). According to R and others (2020), AR is a technology that mixes digital and real objects in the physical world. It focuses on three main features: combining the real and virtual worlds, allowing users to experience it directly, and working in a 3D space.

As research shows Virtual Reality and Augmented Reality are important. This emphasizes the necessity for educators to think about the efficacy of these technologies and engage both educators and students in VR and AR education (Zhao and others, 2023). The potential of Virtual Reality and Augmented Reality to provide compelling and accurate experiences that mimic real-world circumstances is one of the major benefits of its use in the educational field. This helps students learn better through a more hands-on and practical

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approach than traditional methods. AR and VR can also be used for virtual field trips, allows students to explore and understand locations that are difficult or physically inaccessible.

Because they create engaging and dynamic educational settings, VR and AR have had a significant impact on education. They help students stay more focused and remember what they learn better. While technology is important, it is also necessary to consider including it in teaching and deal with problems like limited budgets and poor infrastructure (Shankar et al., 2023). Virtual Reality and Augmented Reality help students and teachers work together and interact in a digital space, making learning more collaborative. These technologies are also beneficial for students with special needs because they can be adjusted to fit each student's needs. However, this use of VR and AR also has challenges that must be solved carefully.

Augmented Reality (AR) is utilized within the realm of mathematics education in Indonesia, with a concentrated examination of Geometry, Algebra, and Statistics. The benefits identified encompass augmented cognitive and affective advancement, whereas the drawbacks are not thoroughly examined within the parameters of our study (Ivan & Maat, 2024). The focus of this book is Augmented Reality in Mathematics Education, emphasizing its positive effects on students' attitudes, motivation, and skills. However, it recognizes several drawbacks, like insufficient infrastructure and a heavy emphasis on software, without specifically discussing the uses of virtual reality. (VR) (İslim et al., 2024).

2. RESEARCH METHODOLOGY

This research uses a development method to create learning media that suits the needs of students. The model used is ADDIE, which consists of several stages such as analyzing needs, designing media, making products, trying out to students, and evaluating the results. At the beginning, researchers looked at what difficulties students have in learning mathematics, especially in building space material. After that, a suitable media design was made, then developed into VR-based media. The finished media is then tried on students to see if it is feasible to use, easy to understand, and can help the learning process. Each stage is carried out in stages so that the media made is truly in accordance with the learning objectives.

Literature study of various relevant academic sources, including scientific journals, research articles, theses, and dissertations that focus on the use of Virtual Reality (VR) and Augmented Reality (AR) technology is the most important thing. The results in this way you can use it and use text and other content that appears on the screen, send it to you, and use media to use VR and AR. high. These sources are systematically reviewed to gain in-depth

insights into the application of immersive technology in improving understanding of mathematical concepts, student engagement, and a more interactive and enjoyable learning experience. However, the articles described also provide an overview of the potential of this technology in helping visualize abstract concepts and providing a realistic learning environment. There are many types of books that can be read and read, which can be used directly or indirectly, and which can be accessed comprehensively that can be used in VR or AR.

Literature Categorization

The reviewed literature discusses the application of Virtual Reality (VR) and Augmented Reality (AR) in mathematics teaching. Article I highlights VR running on an Android system to help visualize spatial geometry, while Article II utilizes AR to support students' understanding of the Pythagorean Theorem. Article III reviews the integration of AR and VR in classroom teaching to improve mathematics understanding and increase interaction. All three articles emphasize improving visualization, participation, and student enthusiasm, and support the implementation of technology-based teaching methods that are relevant and student-focused.

Content Analysis

These three articles explore the use of Virtual Reality (VR) and Augmented Reality (AR) technologies to support mathematics learning, especially in difficult-to-understand topics such as geometric shapes and the Pythagorean theorem. These technologies were developed to demythologize abstract mathematical concepts that are sometimes difficult for students to understand, increase their drive to learn, and to understand through conventional teaching methods. Article I focuses more on Android-based VR for teaching two-dimensional geometric shapes (cubes), with the aim of helping students better understand material about three-dimensional space.

Article II discusses the use of AR for the Pythagorean theorem, which allows students to see direct visualizations of the concept of right triangles directly. Article III discusses the dissemination of the use of VR and AR to prospective teachers, with the aim of preparing them to face the metaverse era in the education sector.

Synthesis of Findings

Based on the review of the three analyzed articles, it can be concluded that Virtual Reality (VR) and Augmented Reality (AR) technologies have a significant role in improving the quality of mathematics teaching. Article I explains that Android-based VR applications can

improve students' understanding of spatial geometry, especially in flat geometric shapes such as cuboids, with the support of high learning motivation and good learning outcomes. Article II shows that the application of AR to the Pythagorean Theorem material can help students understand concepts visually and contextually, which affects engagement and clarity of concepts. Article III highlights the efficiency of AR/VR in creating interactive learning, especially in improving spatial skills and compiling relevant materials to support mathematical literacy.

Evaluation

The information used in this study was obtained through a literature search of three articles related to the topic of utilizing VR and AR in mathematics teaching. The first article was chosen because it presented statistical data on the validity, ease, and effectiveness of Android-based VR media. The second article was taken because it discussed the application of AR in Pythagoras material and mathematical literacy, and the third article highlighted the socialization of the use of immersive technology for teachers. The search process was carried out through a national journal database using relevant keywords. After finding the appropriate article, the researcher read, recorded important information, and classified the findings based on themes and learning indicators, then synthesized to support the analysis of the research results.

3. RESULT & DISCUSSION

This study, which is derived from three different but related articles, explores the impact and application of technology-based learning media - both

Virtual Reality (VR) and Augmented Reality (AR) - in mathematics education. Table 1 summarizes and analyzes the findings of the study.

Table 1. Summary of Article Research Results

Aspect	Article I	Article II	Article III
Validity	91,8% – Highly Val	Literature study states	Very feasible
Practicali	90,7% – Highly Pract	AR is practical, ea accessible	User-friendly
Effectiven	82,6% – Highly Effec	Improves mathematical	Academically effective

Impact	Improves learning outc	Increases concept understanding	Increases student motivatio
Strong Medi	Spaces Simulation a Experimentation	Visualization of abs concepts	Optimal combination of bot

As presented in Table 1, each of the three articles showed improvement in aspects related to student learning. These aspects include validity, practicality, effectiveness, impact, and powerful media for simulation, visualization, and combination.

Article I applies the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model, which includes needs assessment, media design, development process, and effectiveness and practicality testing. Validation was carried out by three validators (lecturers and material experts), while practicality was measured using a questionnaire filled out by students, and effectiveness was evaluated through a learning outcome test. The high level of validation indicates that VR-based learning media has met the eligibility standards both in terms of substance and technicality for use in formal education. The level of visual clarity and interactivity helps understanding abstract concepts in mathematics, especially in spatial geometry materials such as cuboids.

This shows that VR-based learning media can be easily utilized by junior high school students, while increasing their enthusiasm for learning mathematics. Improvement in student learning outcomes was seen after using Android-based VR media, which indicates that this media has a positive effect on understanding and applying mathematics materials.

Article II relies more on literature review to evaluate how effective AR is in clarifying mathematical concepts, especially in geometry and the Pythagorean theorem, and its impact on students' mathematical literacy skills. This study examines various journals and previous research results to strengthen its opinion regarding the impact of AR on students' spatial abilities and mathematical understanding. AR technology greatly helps students understand spatial and geometric concepts. Direct visualization makes material that has been considered abstract become more real. AR has been proven to greatly improve students' mathematical literacy, especially in terms of mathematical communication, logical reasoning, symbolic representation, relationships between concepts, and problem-solving skills.

Article III is designed as a social activity for prospective educators through a webinar. The approach used includes an initial survey, presentation, Q&A session, and assessment to measure how well participants understand VR and AR technologies and their readiness to apply

them in the teaching and learning process. VR offers a deep and immersive experience—ideal for exploring virtual environments such as construction rooms or three-dimensional worlds. Meanwhile, AR has the property of enriching reality by incorporating digital objects—suitable for showing and explaining visual concepts such as flat planes or angles. Both types of media have been shown to improve understanding, accelerate students' memory, encourage interest in learning, and improve learning outcomes.

The results of this study indicate that the creation of learning media using Android-based Virtual Reality (VR) for the topic of flat-sided spatial structures, especially cuboids, has a very positive impact on three main aspects, namely validity, practicality, and effectiveness. Through a validity assessment involving three experts, an average value of 91.8% was obtained, which is included in the "very valid" category. This proves that the media created has met the eligibility standards in terms of content, language, and technical design. According to Supriadi and Hignasari (2019), the validity of learning media is a crucial element that determines its eligibility in helping the learning process, especially when the media uses immersive technology such as VR.

Experts argue that this media is suitable for achieving learning objectives, can visualize 3D objects appropriately, and apply teaching principles that are appropriate for junior high school students. Furthermore, the results of the practicality test showed an average value of 90.7%, which is included in the "very practical" category, where almost all students (22 out of 23 people) stated that this media was easy to use and interesting.

This shows that VR media is very user-friendly, even for students who are not yet familiar with the latest technology. Kerawalla et al. (2006) explained that the practicality of technology-based learning media can be assessed from its easy-to-understand interface design and its ability to reduce students' cognitive load, so that students can concentrate more on the material.

In this study, students can interact directly with the media independently, and the use of the MilleaLab platform facilitates the experience with just an Android device (Fernanda et al., 2024). In terms of effectiveness, the results showed that 82.6% of students succeeded in achieving learning completion, which means that 19 out of 23 students met the minimum completion criteria (KKM). This indicates that the use of VR media has a direct role in improving students' understanding of three-dimensional space concepts such as volume and surface area. Purwati et al. (2020) emphasized that immersive learning media, such as VR, help students form mental images of abstract concepts through simulations that resemble real experiences. This finding is in line with Bruner's learning theory, especially at the enactive

stage, where students learn better when they can interact directly (either physically or virtually) with the learning material Arsyad (2016). This is very important in learning mathematics which is often considered difficult because it requires high spatial visualization skills (Utari et al., 2019). Interestingly, many students in the practicality questionnaire also said that learning with VR is more fun and motivating than traditional methods.

This is in line with research by Inayah et al. (2022), which revealed that young teachers who participated in training on the use of VR and AR felt enthusiastic and ready to develop teaching materials based on this technology. This finding is reinforced by the OECD (2013) which states that learning motivation is one of the main factors in academic success, and digital technology that can attract students' interest will contribute greatly to learning achievement. This study is in line with the findings of Albar et al. (2022) who utilized Augmented Reality (AR) to improve students' understanding of the Pythagorean Theorem. Although the focus of this study is on VR, the basic principle of using media that provides an immersive experience and allows direct interaction with learning objects still has a positive impact on conceptual understanding.

Kerawalla et al. (2006) stated that both AR and VR can create meaningful learning experiences and help students to better understand concepts. Furthermore, this study also provides an important contribution to the educational literature that supports the application of immersive technology in accordance with the objectives of the Independent Curriculum, which emphasizes contextual, experience-based, and student-oriented learning. Inayah et al. (2022) stated that the application of technologies such as VR and AR in the learning process not only encourages educational innovation but also prepares students to face future challenges, including the metaverse era as a new learning space that integrates the physical and digital worlds.

This opinion is supported by Supriadi and Hignasari (2019) who argue that teachers need to be responsive to developments in the era by implementing relevant approaches and technologies so that the quality of learning is maintained properly.

Overall, the results of this study indicate that learning media based on Virtual Reality can improve understanding of mathematical concepts, especially in materials that require spatial visualization. High level of validity, practicality and effectiveness shows that this media is suitable for use in learning and can be a strong alternative choice compared to traditional learning methods. This also further strengthens the relevance of Bruner's learning theory and emphasizes the role of digital media as a tool to deepen students' conceptual understanding. Further research is recommended to explore the application of VR and AR to different topics

and levels of education so that the potential of this media can be maximized in the field of education.

Findings

This study shows that learning using Android-based Virtual Reality (VR) media is very suitable for application in mathematics subjects, especially for spatial geometry material. According to the evaluation results from experts, this media achieved an average score of 91.8% and was declared "very valid" in terms of content, language, and technical aspects (Fernanda et al., 2024). During the implementation, the student response was very positive, as seen from the practicality score which reached 90.7%, which shows that this media is easy to use and interesting (Kerawalla et al., 2006). The increase in student learning outcomes was also significant, where 82.6% of them achieved completion, which shows that this media is "very effective" in supporting the understanding of spatial concepts (Purwati et al., 2020).

In addition to success in cognitive aspects, the use of VR has been shown to increase students' interest and motivation to learn. This is in line with the findings of the OECD (2013) which states that motivation is one of the main factors in academic success. Students feel more motivated and happy when using VR media, thus reducing the boredom they often experience when learning mathematics (Utari et al., 2019). This finding is also supported by the results of research by Albar et al. (2022) which shows that the application of AR in geometry material helps improve mathematical literacy through interactive visualization. From the teacher's perspective, the use of VR and AR also receives strong support. Inayah et al. (2022) revealed that prospective teachers responded positively to the use of technology-based media and were willing to integrate it into their learning. This supports the view of Supriadi and Hignasari (2019) that today's teachers need to utilize technology in learning to face challenges in the digital era and to support learning in the 21st century. Thus, the results of this study not only confirm the success of VR media in improving mathematical understanding but also show its suitability for an adaptive, interactive learning approach that is relevant to the latest developments in educational technology.

CONCLUSION

This study shows that the use of Virtual Reality (VR)-based learning media on the Android platform in spatial geometry material is very appropriate to be applied in the learning process. The media is proven to be valid, useful and successful in enhancing pupils' comprehension of spatial concepts. VR may greatly boost student motivation and engagement in addition to assisting in the achievement of learning objectives. It is made simpler by the

available interactive visualization for students to understand abstract concepts in a more realistic and enjoyable way. The use of VR media is in accordance with the Merdeka Curriculum approach which emphasizes contextual and student-focused learning. With its great potential, VR can be an innovative alternative in teaching mathematics. It is hoped that this media can be further developed for other materials and applied more widely, while being supported by training for teachers so that the use of technology can be more optimal and sustainable.

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