World Journal of Advanced Engineering Technology and Sciences
eISSN: 2582-8266
Cross Ref DOI: 10.30574/wjaets
Journal homepage: https://wjaets.com/

(Research Article)

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Analyzing demand for virtual reality based adaptive learning design in engineering faculty of universitas negeri Makassar Indonesia

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World Journal of Advanced Engineering Technology and Sciences, 2024, 13(01), 505–515

Publication history: Received on 10 August 2024; revised on 22 September 2024; accepted on 25 September 2024

Article DOI: https://doi.org/10.30574/wjaets.2024.13.1.0435

Abstract

This research aims to analyze the needs of students regarding the application of Virtual Reality (VR) technology in learning at the Faculty of Engineering. The main focus is to understand how VR can support adaptive learning and improve students' practical ability according to individual ability. This research uses a needs analysis method involving a survey of engineering students. Data collection was conducted through questionnaires and observations to identify students' constraints, needs, and interests in VR-based learning. The collected data were then analyzed quantitatively and qualitatively. The results show that 85% of students struggle to understand complex engineering concepts, and 90% show high interest in using VR for skills practice in a safe environment. In addition, students expected a more interactive and personalized learning approach. Important features they expected included automatic adjustment of difficulty levels and immediate feedback during practice. The findings of this study confirm the importance of integrating VR into engineering education, especially in creating an adaptive learning environment that meets individual needs. VR has the potential to improve students' understanding of concepts and practical skills, as well as to support the development of curriculum that are more relevant to the needs of modern industry.

Keywords: Virtual Reality; Adaptive Learning; Engineering Education; Training Skills.

1. Introduction

Virtual reality (VR) technology has been a significant innovation in education, offering students an immersive and realistic learning experience like never before. The application of VR in schools has been shown to increase student motivation and improve learning outcomes compared to conventional methods [1]. By providing simulations that mimic real-world environments, this technology facilitates experiential learning, enhancing visualization and understanding of abstract concepts [2]. VR is proven to be particularly effective in subjects such as history and science, where traditional teaching methods may not fully engage students [3].

In addition, VR can foster dialogical skills in math education by stimulating critical thinking and encouraging interaction among students [4]. However, integrating digital technology into education also presents challenges that need to be overcome [2]. Overall, VR is a promising tool for creating more accessible, engaging and effective learning experiences in the digital age. In education, VR offers immersive learning by presenting simulations similar to the real world, thus facilitating experimental and hands-on learning. This technology not only improves visualization and understanding of abstract concepts, but also increases student engagement and motivation.

VR is rapidly being used in engineering education as a useful learning tool, particularly to introduce students to complicated technological scenarios that would be impossible or expensive to implement in the real world. VR may be utilized to teach technical skills through safe and regulated practical experiences [5]. This technology not only helps

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students improve their technical skills, but it also promotes the development of adaptive learning, which allows students to study at their own speed and ability.

Integrating technology into education is critical as we go from Industry 4.0 to Society 5.0, which prioritizes human-centered values [6]. Educational institutions must adapt by embracing creative technology-based learning approaches that break down traditional barriers [7]. Indonesia's "Merdeka Belajar" curriculum intends to promote creative learning that is in line with student requirements and 21st century abilities such as critical thinking, communication, teamwork, and creativity [7] [8]. To tackle the difficulties of Society 5.0, educators must build competences such as mastery of 4C abilities, pedagogical knowledge, and the capacity to design inventive learning experiences (Suwandi, 2020). To prepare learners for a dynamic future in a highly intelligent society, this educational change necessitates striking a balance between technological integration and character development [6] [9]. Engineering education should include theory and hands-on experience with new technologies such as virtual reality, artificial intelligence, and computer simulation [8].

Technology-based education is becoming increasingly important in educating students for Society 5.0 and the Fourth Industrial Revolution. VR can increase students' attention, motivation, and technological abilities [10]. VR implementation also assists students in overcoming anxiety and increasing confidence in their teaching practice [11]. Curriculum and teaching techniques must be modified to match 21st-century expectations, with a focus on developing the 4C skills: critical thinking, communication, cooperation, and creativity [12]. To educate students for the difficulties of the Fourth Industrial Revolution, higher education should include methodologies based on discovery, assembly, and market demands, as well as include industry practitioners as teachers [12].

Virtual Reality (VR) is a useful learning tool for engineering because it simulates real-world settings, allowing students to practice and understand difficult scenarios without the need for actual equipment. VR can develop realistic simulation settings in which students may safely and accurately operate equipment, assemble components, and solve technical difficulties. VR increases student involvement in the learning process by giving interactive experiences that closely reflect the actual world, allowing them to immediately apply the theories they acquired through simulations. Furthermore, employing VR improves students' grasp of abstract or complex ideas that are difficult to teach using only words or pictures. [13].

Adaptive learning is the notion of tailoring the educational process to the requirements, talents, and unique learning styles of students [14] Teaching materials and procedures are not used evenly in adaptive learning; rather, they are altered based on each student's level of knowledge, pace, and desired learning style. This enables students who comprehend the information quickly to go to more complicated levels, while those who require more time can review the material until they master it. At the Faculty of Engineering, adaptive learning has grown in importance because engineering students confront a variety of obstacles that necessitate different techniques for each individual to properly acquire both practical and theoretical abilities.

Virtual Reality (VR) bolsters the notion of adaptable learning by providing simulated settings that may be tailored to students' specific requirements. Students may practice technical skills at various levels of difficulty using VR, and teachers can create learning situations that are tailored to each individual's ability [15]. VR enables students to study at their own speed, repeating simulation exercises as needed until they are comfortable and competent [16]. VR's versatility enables individualized learning and guarantees that each student obtains an appropriate learning experience based on their needs and skills [17].

Several reasons contribute to the limited utilization of virtual reality (VR) technology in UNM's engineering learning procedures. Despite its benefits, problems such as students' low computer skills and insufficient resources might prevent effective needs assessment [18]. This raises questions about the barriers to VR adoption among FT-UNM students, how this technology can be integrated into the curriculum, and how VR can support adaptive learning by providing learning experiences that are flexible and tailored to individual student abilities, allowing for the optimal development of practical skills.

2. Literature review

2.1. Virtual Reality (VR) Based Learning

Virtual Reality (VR) is a technology that allows people to view and interact with digital surroundings that are meant to simulate real-world experiences. Individuals can enter virtual environments using VR headgear and associated equipment, which provide immersive three-dimensional graphics, realistic sound, and interactive components [19] [20]. This technology enables users to navigate and interact with things inside the virtual world, resulting in a rich and full experience. VR has emerged as a viable tool in a variety of industries, including education, because to its capacity to enhance learning experiences [21].

2.2. Adaptive Learning

Adaptive learning is an educational technique that tailors the learning experience to students' specific requirements, leveraging technology and data analysis to improve learning quality [22] [23]. This approach analyzes students' learning styles and offers suitable information to meet classroom diversity [24]. Adaptive learning methods based on artificial intelligence (AI) have been shown to improve student engagement and motivation. Although promising, its adoption involves obstacles like as infrastructure needs, teacher training, and privacy concerns [25]. Adaptive Learning has two main characteristics: 1) personalization, which creates unique learning experiences tailored to each student's personality, interests, and performance, enhancing academic improvement and satisfaction [26]; and 2) dynamic adjustment, which uses emerging algorithms and technologies, such as AI, to modify content and teaching methods in real-time, ensuring that students learn at their own pace [27].

2.3. Requirements Analysis in Instructional Design

In curriculum design, requirements analysis is a systematic method that identifies learners' educational needs and competencies [28]. This approach include collecting and analyzing data to better understand learners' existing situations, obstacles, and expectations [29]. In technology-based learning, Requirements Analysis is critical to ensuring that technology is successful in supporting learning objectives [28] It also aids in the identification of subjects to be delivered in multimedia formats via curriculum revision [28]. Furthermore, Requirements Analysis may be utilized to discover the character values that learners value, as well as the most difficult language aspects and abilities [30]. The findings of the Requirements Analysis serve as the foundation for generating appropriate instructional materials and learning strategies [28] [29].

2.4. Analysis of VR Implementation in Engineering Education

Previous research has demonstrated that the use of VR technology in engineering education may significantly improve conceptual comprehension, student engagement, and practical abilities. [31] investigated the application of VR in mechanical engineering education and discovered that students who participated in VR simulations had a better comprehension of machine dynamics principles than those who employed traditional learning techniques. This research underlines the relevance of interaction and imagery in helping students understand complicated ideas.

Found that virtual reality had a favorable impact on engineering education, particularly in terms of student motivation and satisfaction. In their research, VR was utilized to build interactive simulations that enabled students to actively participate in the learning process, which showed to be more effective in catching their attention and interest in the learning content [32]. This suggests that VR is not only a learning tool, but also a way to improve the whole learning experience.

Furthermore, [33] examined the use of VR in electrical engineering education. The findings revealed that students might gain a better understanding of the interplay of electrical circuit components by using virtual simulations that allowed them to experiment and see the effects of their adjustments. This study demonstrates how VR may create a secure and controlled learning environment in which students can refine practical skills without the fear of making mistakes that could have serious repercussions.

Have found that using VR in vocational education improves immersive and practical learning experiences, assisting students in developing the technical skills required to meet workplace obstacles [34]. This study adds to the body of evidence that VR can be used to create learning experiences that are relevant to industrial demands.

3. Research Methods

The study method employed in this work combines qualitative and quantitative methodologies to examine the demands and possible development of VR for enabling adaptive and practical learning in engineering. Requirements Analysis intends to create a Virtual Reality (VR)-based learning program at the Faculty of Engineering. This approach includes activities such as student surveys to identify needs in VR-based learning, observations to gather relevant data on students' challenges and needs in engineering education, and quantitative data collection via questionnaires distributed to 50 engineering students to assess their understanding of engineering concepts, engagement, access to learning resources, and digital skills.

A thorough Requirements Analysis not only helps to improve curriculum design, but it also assures that the technology used provides value to the learning process. The requirements analysis process generally consists of four stages: organizational screening, data gathering, analysis, and action planning [35]. Requirements analysis ensures that instructional information is relevant and applicable, increasing the efficacy of interventions [36].

4. Results and Discussion

Requirements analysis is a key first step in building technology-based learning programs such as Virtual Reality (VR), particularly adaptive learning at UNM's Faculty of Engineering. A requirements analysis reveals numerous key issues. First, students want media that allows them to practice and acquire real engineering skills in a safe and regulated setting. VR technology may provide simulations that closely mirror real-world industrial situations, such as practicing operating machinery and gadgets without posing actual dangers or causing equipment damage. This is supported by [37] research, which claims that VR technology allows students to participate in simulations that mimic real-world settings, reducing physical hazards and equipment damage. Second, there is a demand for individualized learning, which allows students to study at their own speed and level. Based on the study findings obtained through observation of the data from the needs analysis for VR-based learning, as illustrated in Figure 1.

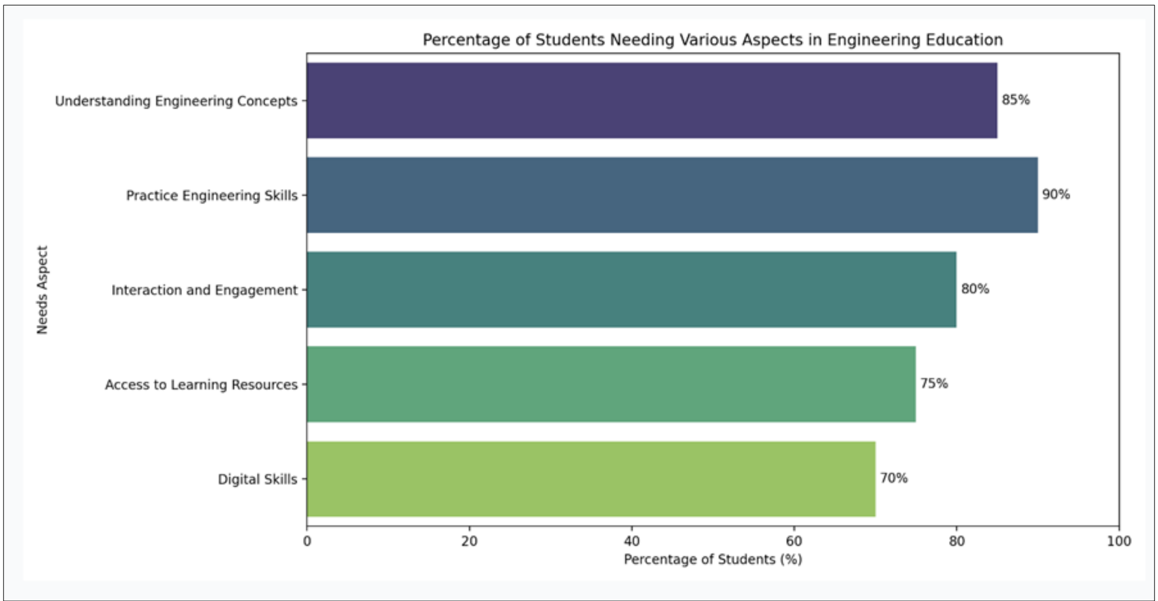

Figure 1 Results of Student Needs Survey for VR-Based Learning

The findings of the needs analysis based on surveys performed among students at the Faculty of Engineering show that there is a substantial demand for the deployment of VR-based learning. A total of 85% of students had difficulty grasping complicated engineering ideas, prompting them to seek more interactive and immersive learning experiences. According to [38] and [39], VR offers immersive settings that increase student motivation and interest, making learning more fun. Furthermore, research by [40] and [41] suggest that VR aids in visualizing complicated engineering topics by allowing students to engage with 3D models and simulations, hence improving comprehension. Furthermore, 90% of students expressed a strong desire to practice technical skills in a safe atmosphere where they could conduct experiments without the hazards connected with physical laboratories. [42] discovered that this method is consistent with the necessity for practical components in vocational training, stressing psychomotor abilities that are required for engineering disciplines.

Figure 2 Photo of Student VR Learning Needs Assessment Activities

Students also value connection and involvement in the learning process, with 80% preferring a more engaging method to increase motivation. 75% of students stated a desire for better access to learning resources, suggesting that they would want to have more things to help them comprehend. Finally, 70% of students acknowledge the value of digital skills and wish to increase their capacity to use current technologies, such as virtual reality, to aid in the learning process. These findings serve as a solid foundation for developing a VR-based curriculum that can suit the learning demands of engineering students.

Table 1 shows the results from the questionnaire measuring students' understanding of engineering concepts. This questionnaire is designed to evaluate how well students understand the basic concepts in the field of engineering and the difficulties they face.

Table 1 Results of the Survey of Student Needs for VR-Based Learning

No	Statement	SA (%)	A (%)	N (%)	D (%)	SD (%)
1	I feel confident in practicing basic engineering skills.	40	30	20	5	5
2	I am able to follow work safety procedures when practicing.	45	35	10	5	5
3	I can use engineering tools and equipment well.	50	30	15	3	2
4	I understand how to maintain and repair engineering tools.	35	25	25	10	5
5	I can analyze and solve problems that arise during practice.	30	40	20	5	5
6	I feel comfortable working in a group when practicing engineering.	55	30	10	3	2
7	I am able to explain the steps taken in engineering practice.	45	35	15	3	2
8	I often practice engineering skills outside of class hours.	30	20	25	15	10
9	I get constructive feedback from lecturers about my practice.	40	40	10	5	5
10	I can apply the theories I have learned to engineering practice.	50	30	15	3	2

The data above shows that the majority of students feel confident in performing basic technical skills (70% agree or strongly agree). However, other areas require development, such as comprehending the maintenance and repair of technological equipment, to which only 60% of students agreed. These questionnaire findings can be utilized to create extra training sessions that focus on areas for growth.

Table 2 shows the findings of a questionnaire that evaluated student involvement and participation in learning, notably in the discipline of engineering. This questionnaire includes various comments on the amount of student involvement and interaction during the learning process.

Table 2 Student interaction and engagement in learning, particularly in the field of engineering

No	Statement	SA (%)	A (%)	N (%)	D (%)	SD (%)
1	I actively participate in class discussions.	35	40	15	5	5
2	I often ask the lecturer if there is something I do not understand.	30	45	10	10	5
3	I am involved in study groups with friends.	40	35	15	5	5
4	I provide constructive feedback to classmates in group assignments.	25	30	20	15	10
5	I feel comfortable sharing ideas and opinions in class.	50	30	10	5	5
6	I participate in extracurricular activities related to the course.	20	25	30	15	10
7	I feel involved in the material taught in the learning process.	40	35	15	5	5
8	I utilize online platforms to interact with lecturers and friends.	30	40	15	10	5
9	I regularly attend consultation sessions with lecturers.	25	30	20	15	10
10	I feel that VR-based learning increases my engagement.	45	35	10	5	5

According to the research, the majority of students are actively participating in class discussions (75% agree or strongly agree) and believe that VR-based learning improves their involvement (80% agree or strongly agree). However, certain aspects may be improved, such as participating in study groups and offering constructive comments to peers. The questionnaire data may be utilized to create more interactive learning techniques and increase student participation in the learning process.

Table 3 shows the findings of the questionnaire, which assessed students' access to learning materials. This questionnaire includes multiple comments on the extent to which students can use various learning materials during the learning process.

Table 3 Measurement of Student Access to Learning Resources

No	Statement	SA (%)	A (%)	N (%)	D (%)	SD (%)
1	I have good access to online learning materials.	40	30	20	5	5
2	I often use e-books or online journals to study.	35	30	25	5	5
3	I can easily access the university library.	25	35	20	15	5
4	I feel that the available learning resources support my learning process.	45	40	10	5	0
5	I have access to relevant learning videos.	30	40	20	5	5
6	I often use online learning platforms to get information.	50	30	15	5	0
7	I have access to learning aids such as simulations and software.	20	25	30	15	10
8	I feel that there are enough learning resources available for my courses.	40	35	15	5	5
9	I get support from lecturers in accessing learning resources.	30	30	25	10	5
10	I find it difficult to access some learning resources.	5	10	15	30	40

According to the statistics gathered, the majority of students believe they have adequate access to online learning resources and often utilize online learning platforms (80% agree or strongly agree). However, other factors require work, such as access to learning materials and ease of access to the university library, to which only 55% of students believe they have enough access. These questionnaire findings can be used as a guide to enhancing the availability and accessibility of more effective learning materials for students.

Table 4 displays the results of the questionnaire that assessed students' digital skills. This questionnaire contains various assertions about students' digital skills in the context of learning.

Table 4 Student's Digital Skills

No	Statement	SA (%)	A (%)	N (%)	D (%)	SD (%)
1	I am able to use productivity software such as Microsoft Office.	40	30	20	5	5
2	I am comfortable using online learning platforms.	35	45	10	5	5
3	I can search for information effectively on the internet.	50	30	15	5	0
4	I am able to use collaboration applications such as Google Drive.	30	40	20	5	5
5	I can create engaging presentations using software such as PowerPoint.	45	35	15	5	0
6	I have basic programming skills.	20	25	30	15	10
7	I am able to use social media effectively for academic purposes.	30	40	20	5	5
8	I can efficiently manage files and data on my computer.	35	35	25	5	0
9	I know how to protect my personal data online.	25	30	25	10	10
10	I feel my digital skills are good enough to support my learning.	40	40	15	5	0

According to the collected data, the majority of students think they have great digital abilities, particularly in the use of productivity software and finding internet information, with 70% agreeing or strongly agreeing. However, other areas require development, including fundamental programming abilities and personal data protection, where 25% of students acknowledged a lack of expertise. The findings of this questionnaire can help the Faculty of Engineering build more effective digital skill upgrading programs. ore effective digital skill upgrading programs. ore effective digital skill upgrading programs.

4.1. Potential for VR Interface Development

The potential for building Virtual Reality (VR) interfaces in adaptive learning is substantial, especially in terms of establishing a learning environment that reacts to the specific requirements of full-time students at the University of New Mexico. An excellent virtual reality interface may recreate technical settings relevant to students' subjects of study while allowing for intuitive interaction. One significant advantage is the interface's ability to change the difficulty level of assignments in real time based on student performance. This allows for more individualized learning, with each student progressing at their own rate based on their ability.

Furthermore, an interactive and adaptable VR interface may give quick feedback on activities completed by learners. For example, in engineering education, a virtual reality interface may detect faults in technical practice and provide prompt remedial suggestions. These elements not only boost intellectual knowledge, but also pupils' practical abilities. By leveraging this potential, VR interfaces can become strong tools for aiding adaptive learning, allowing for dynamic curriculum revisions adapted to students' specific requirements and the problems they may confront in the real world.

Figure 3 shows the survey results on the potential for VR interface development, conducted among 50 Engineering Faculty students, regarding features expected to support adaptive learning

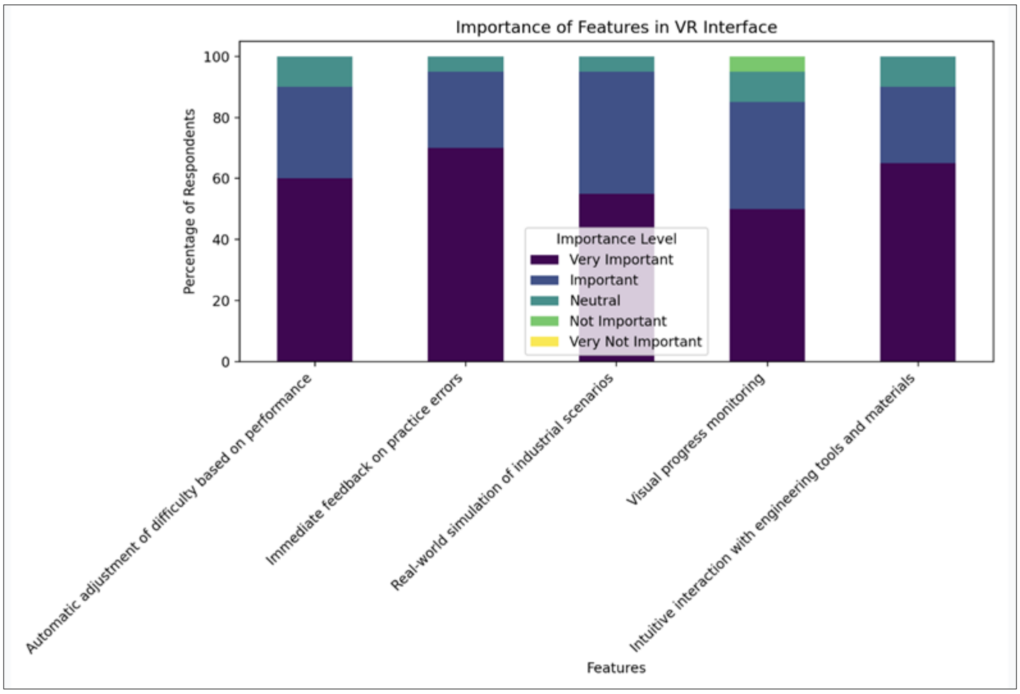

Figure 3 Engineering Students' Perspectives on VR Interface Development Potential

The survey results indicate many notable conclusions that demonstrate the enormous potential for creating an adaptable VR interface for technical learning. Automatic difficulty adjustment is highly regarded, with 90% of respondents rating it as important or extremely important. This shows that students want a system that can adjust the degree of difficulty based on their performance, allowing them to study at a speed and level that matches their skills.

Additionally, 95% of respondents believe that rapid feedback on practice errors is necessary or extremely significant. Students believe that direct supervision in technical practice is vital for swiftly recognizing and correcting errors. This feature may greatly improve the learning process and the application of technical abilities.

The modeling of real-world industrial settings has received a lot of attention, with 95% of respondents rating it as important or extremely important. This function allows students to interact with real-world industrial scenarios, underlining the relevance of their education in the workplace. Creating an interface that can accurately show these events will significantly improve students' ability to confront professional obstacles.

Furthermore, intuitive interaction with technical tools and materials, which 90% of respondents rated as vital, emphasizes the importance of a user-friendly interface in improving student engagement and comfort throughout the educational process. Overall, these findings imply that the creation of VR interfaces should focus dynamic adaptation, quick feedback, and industry-related simulations to produce a more customized, efficient, and relevant learning experience for the Faculty's of Engineering students.

5. Conclusion

This study concludes that the use of Virtual Reality (VR) technology in learning within the Faculty of Engineering has tremendous potential to improve practical skills and deepen knowledge of complicated engineering ideas. VR creates a secure and regulated learning environment while also encouraging adaptive learning by allowing students to modify the difficulty level and receive quick feedback. According to survey data, the vast majority of students show a great desire for more interactive and immersive learning techniques, particularly in terms of understanding engineering topics. As a result, incorporating VR into the engineering curriculum may successfully address these objectives, boost learning motivation, and educate students to face industrial issues in the era of industrial 4.0 and Society 5.0. Furthermore, developing a more adaptive and realistic VR interface may be essential for supporting personalized learning tailored to individual student capabilities.

Acknowledgment

Thanks to the Directorate of Research, Technology, and Community Service (DRTPM) of the Ministry of Education, Culture, Research, and Technology for providing funding for the Applied Research in 2024, which made this study possible. We also extend our deepest appreciation to the Rector of Universitas Negeri Makassar, the Head of the Research and Community Service Institute, and the Dean of the Faculty of Engineering, Universitas Negeri Makassar, for their support, facilities, and opportunities provided during the research process. Without the assistance from these parties, this research would not have been successfully conducted and yielded meaningful results.

Compliance with ethical standards

Disclosure of conflict of interest

The Authors had no conflict of interest to declared.

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