The Eurasia Proceedings of
Educational & Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2024

Volume 36, Pages 12-24

ICRESS 2024: International Conference on Research in Education and Social Sciences

From Limitations to Opportunities: A Systematic Literature Review of Application Virtual Reality

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Abstract: The use of Virtual Reality (VR) is rapidly gaining popularity, particularly in the educational sector. VR is now widely recognized as an effective tool for enhancing the learning process. This is primarily because VR is capable of stimulating immersive and interactive learning experiences, which have been shown to significantly impact the quality of education. Although virtual reality (VR) has multiple advantages in the learning process, it is indisputable that its usage in Indonesian schools is currently limited. Therefore, a systematic literature review has been conducted to identify and analyze previous research on the development, benefits, and challenges of using VR in Indonesian education. The review aims to provide a foundation for further research in optimizing the potential of VR in education in Indonesia. Utilizing a Systematic Literature Review referred to the 2020 PRISMA guidelines, we retrieved 7381 articles from the Scopus and ERIC databases conducted on March 27, 2024. However, only 35 articles satisfied the eligibility criteria for subsequent analysis, employing the meta-synthetic analysis method. The research findings indicate that the (1) use of VR in Indonesia tends to fluctuate, is mostly focused on the fields of science and technology, and is usually implemented at the high school level; (2) Mobile VR-based HMDs technology is the preferred choice due to its affordability, accessibility, and quality; (3) The implementation of VR has been proven to increase student interest and motivation, hence enhancing the knowledge and effectiveness of learning; and (4) availability of facilities and infrastructure, teacher and student readiness, completeness of material content, and health impacts are challenges that need to be followed up. Virtual Reality (VR) has the potential to improve education in Indonesian schools despite current challenges greatly. This research lays the foundation for future development to maximize VR's benefits and address its limitations in the learning process.

Keywords: Learning innovation, Virtual reality, Immersive learning

Introduction

The realities of the 21st century have brought about a disruptive era, where the rapid development of technology has caused a profound impact on various aspects of life, including education. With technology advancing at an unprecedented rate, the dynamics of learning are swiftly evolving, leading to significant transformations in the field of education. The undeniable truth is that technology has profoundly impacted education, necessitating significant adaptations in how we learn (McGovern et al., 2020; Sholihin et al., 2020). Quoting the term proposed by Prensky (2001), students are currently can be classified as digital natives, who have been exposed to the digital technology environment since birth, possess a remarkable capacity to adapt to technological advancements, and rely heavily on digital technology in various aspects of their lives, including education (Senadheera et al., 2024; Turner, 2015). Undeniably, incorporating digital technology in the learning process is

imperative to remain relevant to current developments and meet the diverse needs of students in the 21st century. Therefore, all educational stakeholders must embrace and implement the rapid evolution of technology to enhance the learning process.

Integrating digital technology into learning and teaching activities is not only relevant to the characteristics of students as digital natives (Elaoufy, 2023), but also has been unequivocally shown to offer significant advantages for both students and teachers by enhancing the effectiveness and efficiency of the learning process (Elmira et al., 2022; Rahayu et al., 2022; Sartono et al., 2022). Although digital technology in learning provides various benefits, it should be noted that identifying, selecting, and providing appropriate technology is a challenge for educators (McGovern et al., 2020). Staying abreast of the latest trends in education technology is imperative for educators to ensure that they are equipped with the necessary knowledge to evaluate and select the most suitable and effective technologies that can significantly enhance their students' learning experiences. Therefore, educators must continuously update themselves with the latest advancements in their field to make informed decisions about integrating technology into their teaching methodology.

Virtual Reality (VR) is an undisputedly powerful and cutting-edge technology that holds immense potential for revolutionizing the way we learn in the 21st century. It is worth noting that education is one of the top four fields that frequently utilizes Virtual Reality technology (Suh & Prophet, 2018). VR's main principle of combining three-dimensional aspects, images, and sound enables it to create a simulated environment that allows users to interact directly with the virtual world created, providing users with a sense of physical involvement in the simulated environment (Jensen & Konradsen, 2018; Kamińska et al., 2019; Neelakantam & Pant, 2017).

The application of Virtual Reality (VR) in a learning context is highly promising. It aligns perfectly with the latest technological advancements and offers numerous benefits for the learning process, both cognitive and non-cognitive (Asriadi et al., 2023; McFaul & FitzGerald, 2020). In fact, Virtual Reality technology is described as a 21st-century learning media so that it can be an answer to changes in the learning styles of the digital native generation (Radianti et al., 2020; Sholihin et al., 2020). Thus, Virtual Reality (VR) not only promises to revolutionize learning approaches but also opens the door to more immersive, engaging, and adaptive learning experiences for an increasingly digitally connected generation.

From a theoretical perspective, it cannot be denied that implementing virtual reality in the learning process offers several significant advantages for developing educational quality. However, in the Indonesian context, the use of virtual reality in classrooms is still lagging compared to other countries (Asriadi et al., 2023; Widiyatmoko et al., 2023). This is confirmed by researchers' searches on the Scopus database, which found that virtual reality research in the educational context in Indonesia in the period 2001-2023 only contained 112 out of a total of 6,581 such research studies in the world and placed Indonesia in 17th place. This indicates a gap between the potential of virtual reality technology in learning and the reality of its application in Indonesia. It is imperative that if virtual reality technology delivers significant benefits in learning in Indonesia, then there should be a marked increase in research related to this topic. In light of this gap, this systematic literature review research aims to identify and analyze the advancements in the application of virtual reality in Indonesia. Through this comprehensive analysis, we expect to generate valuable recommendations for the future development of research and application of virtual reality (VR) technology in Indonesia. The primary focus of this research is to address the following research question (RQ):

1. How is Virtual Reality (VR) research trend in the Indonesian educational context?
2. What Head-mounted displays (HMDs) technology is used in implementing Virtual Reality (VR) in Indonesia?
3. What are the opportunities for implementing virtual reality (VR) in the learning process in Indonesia?
4. What are the limitations of implementing virtual reality (VR) in the learning process in Indonesia?

Method

This research uses the Systematic Literature Review method guided by the PRISMA 2020 guidelines (Page et al., 2021) which is aimed at reviewing various previous research and identifying information related to the application of virtual reality in Indonesia in a comprehensive manner. The first step, the identification of data sources was carried out on March 27 2024 through the Scopus and ERIC databases with the following query string (Table 1).

Table 1. Keyword for database

Databases	**Number of Record**	***Query String***
ERIC	323	"Virtual Reality" OR "VR" AND "School" OR "Classroom"
Scopus	7.058	TITLE-ABS-KEY("Virtual Reality" OR "VR" AND "School" OR "Classroom")

The data that has been identified is then subjected to a selection process to eliminate articles that do not meet the criteria listed in Table 2. As a result, 300 articles are considered relevant, but only 144 articles can be accessed openly. After identification, the selected data was then filtered to remove articles that did not meet the criteria listed in Table 2. From the results of this filtering, there were 112 relevant articles, but only 68 articles were freely available. The obtained articles undergo a rigorous verification process, with a specific focus on thoroughly evaluating the abstract and full text, to determine their suitability for use in a research context. Only articles that meet the following criteria are included: (1) relevance to the context of Virtual Reality (VR) in the field of education in Indonesia; (2) application in the learning process. After the selection process, we have obtained 35 articles that will serve as objects of further analysis. For complete details of the selection process, refer to Figure 1 below.

Table 2. Eligibility criteria

Inclusion Criteria	**Exclusion criteria**
1) The document type is a journal article or conference paper.	1) Types of documents other than journal articles or conference paper
2) Publication in English.	2) Publication not in English.
3) Publication in January 2001 to December 2023	3) Publication other than 2001-2023
4) The research location was carried out in Indonesia.	4) The research location is not in Indonesia or it is not clear.

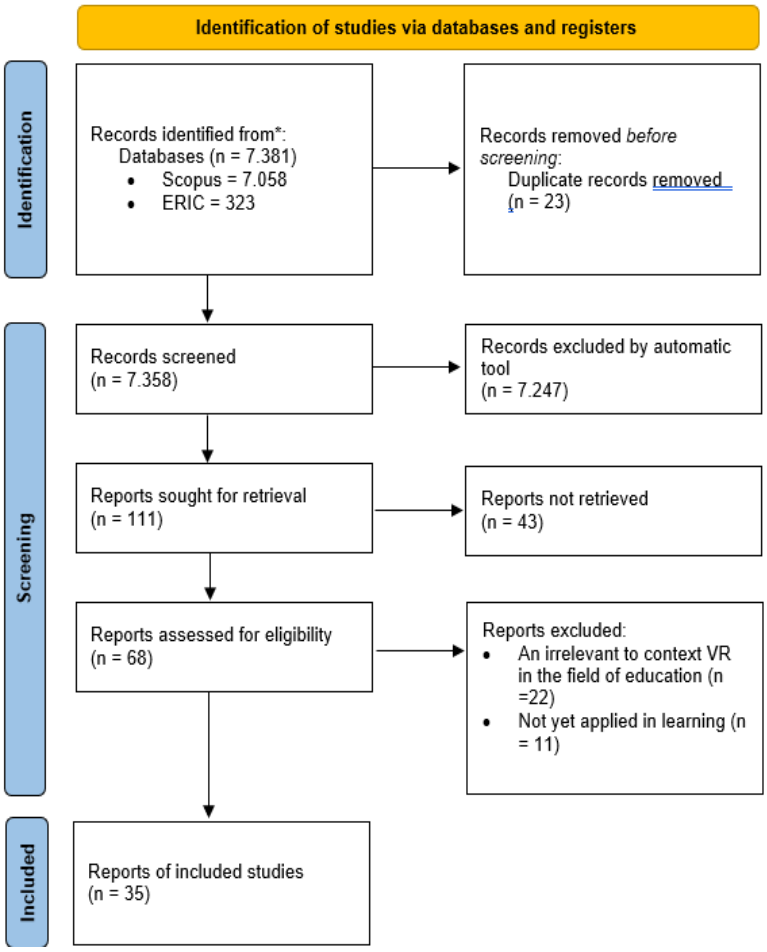

Figure 1. Prisma flow diagram

Results and Discussion

After undergoing a systematic selection process, 35 articles were obtained that meet our eligibility criteria. Intensive identification and analysis have been conducted on these articles to produce a comprehensive synthesis of information, specifically focusing on the utilization of virtual reality in the educational context of Indonesia. To view the complete results of our article identification process, kindly refer to Table 3.

Table 3. List of related articles

Source	EL*	Subject	Types of HMDs	Opportunities to Education	Limitations in Implementation
Sujarwo et al., (2023)	JHS	Social Studies	Mobile VR	Learning outcomes.	Limited material coverage, difficulty creating content, and Expensive cost
Safitri et al., (2023)	JHS	Social Studies	Mobile VR	Learning outcomes.	Infrastructure availability
Asril et al., (2023)	ES	Islamic Education	Mobile VR	Motivation, interest, and learning effectiveness	Not mention
Kurniawan et al., (2023)	HE	Not specific	Standalone VR	Interest and learning effectiveness	Infrastructure availability, Health impacts, and Expensive cost.
Asriadi et al., (2023)	ES	Social Studies	Mobile VR	Motivation, interest, and learning effectiveness.	Not mention
Sukaridhoto et al., (2023)	VHS	Telecommunication	Standalone VR	Practice skills and knowledge	Expensive cost.
Soenarto et al., (2023)	VHS	Digital Engineering	Mobile VR	Practice skills and knowledge.	Limited material coverage.
Widiyatmoko et al., (2023)	JHS	Natural Science	Mobile VR	STEM literacy.	Not mention.
Sukmawati et al., (2023)	ES	Natural Science	Mobile VR	Knowledge and Interest.	Technical issues and health impacts.
Setyowati et al., (2023)	SHS	History	PC-Based	Learning outcomes.	Not mention.
Iasha et al., (2023)	ES	Cultural learning	Mobile VR	Motivation and literacy.	Not mention.
Noviana et al., (2023)	SHS	History	Standalone VR	Interest and participation.	Infrastructure availability and health impacts.
Buchori & Osman, (2023)	JHS	Mathematics	Not specific	Learning outcomes and learning completeness	Not mention.
Rafiq et al., (2022)	HE	Electrical engineering	PC-Based	Knowledge and participation.	Health impact and expensive cost.
Herwin et al., (2022)	ES	Thematic	Mobile VR	Motivation, participation, and knowledge.	Limited material coverage.
Sulisworo et al., (2022)	ES	Not Specific	PC-Based	Knowledge	Technical issues.
Rohayati et al., (2022)	JHS	Language	Not specific	Knowledge and language skills	Not mention.
Ernawati & Ikhsan, (2021)	SHS	Chemistry	Standalone VR	Learning outcomes.	Limited material coverage and difficulty creating content.
Ramansyah et al., (2021)	ES	History	Mobile VR	Knowledge and learning effectiveness.	Not mentions.
Shepa et al., (2021)	SHS	Physics	Mobile VR	Knowledge	Infrastructure availability.
Hasanudin et al., (2021)	ES	Not specific	Mobile VR	Motor skills and learning completeness.	Technical issues.
Maulana & Purnomo,	VHS	Electrical engineering	Not specific.	Knowledge.	Not mention.

(2021)					
Ramansyah et al., (2021)	JHS	Natural science.	Mobile VR.	Knowledge and environmental awareness.	Not mention.
Monita & Ikhsan, (2020)	JHS	Natural Science	Mobile VR	Knowledge and interest.	Difficulty creating content
Ikhsan et al., (2020)	SHS	Chemistry	Mobile VR	Critical thinking skills	Limited material coverage
Saputro & Setyawan, (2020)	JHS	Physics	Not specific.	Learning outcomes and learning completeness.	Not mention.
Sholihin et al., (2020)	HE	Business	Not specific.	Motivation, interest, and ethical efficiency.	Limited material coverage.
Juhana et al., (2020)	HE	Computer engineering	PC-Based	Interest and comfort in learning.	Not mention.
Astuti et al., (2020)	SHS	Chemistry	Mobile VR	Critical thinking and scientific attitudes	Infrastructure availability.
Kurniawati et al., (2020)	SHS	Biology	Mobile VR	Knowledge	Not mention
Suleman et al., (2019)	SHS	Chemistry	Mobile VR	Motivation, interest, and learning effectiveness.	Not mention
Amiati, (2019)	SHS	Chemistry	Mobile VR	Knowledge	Not mention
Nurhadi et al., (2019)	HE	Language	Mobile VR	Language skills	Technical issues.
Bakar et al., (2019)	SHS	Chemistry	Not specific	Participation and creative thinking skills.	Not mention.
Zikky et al., (2018)	JHS	Natural Science	PC-Based	Knowledge and interest	Technical issues.

Note: ES = elementary school, JHS = Junior High School, SHS = Senior High School, VHS = Vocational High School, HE = Higher Education*

Since 2010, there has been a wave of technological disruption related to Virtual Reality (VR), with the emergence of various innovations that have significantly changed the VR technology landscape (Antón-Sancho et al., 2022). One of the important milestones in the development of VR was the development of Head-mounted displays (HMDs) technology in 2013, which marked the appearance of the first version of the Oculus Rift. The emergence of this technology not only created intense competition in the HMD market but also had a significant impact in revolutionizing the accessibility of Virtual Reality (VR) technology as a whole. This has become a historic milestone in expanding the reach of this technology to various fields, including education, leaving no doubt about its unparalleled potential and impact (Jensen & Konradsen, 2018).

In the Indonesian context, the application of virtual reality (VR) technology was only discovered in 2018 when virtual reality using an Oculus Rift was used to learn about the solar system at the junior high school level (Zikky et al., 2018). Furthermore, in Figure 1 it is presented that the development of publications related to VR in the Indonesian educational context shows a fluctuating trend, which can be interpreted as its application in the learning context still not receiving serious attention. This is in line with various previous studies, which state that the use of virtual reality in Indonesian classrooms is still very limited because it is dominated by the entertainment sector (Asriadi et al., 2023; Habibah et al., 2021; Widiyatmoko et al., 2023). Figure 1 indicates a significant spike in 2023, which will undoubtedly serve as a crucial impetus for promoting the adoption of VR technology in the education sector of Indonesia.

Through analysis of Figure 2, it can be seen that the implementation of VR in the educational context in Indonesia can be applied at various levels of education, both higher education and lower education. Previous findings by Antón-Sancho et al. (2022) stated that the application of VR in an educational context is mainly applied to vocational education or higher education. However, in the Indonesian context, there is a contradiction, where vocational education and higher education are the lowest in adopting Virtual Reality (VR), and it is precisely senior high schools that dominate the use of VR in learning in Indonesia. These differences reflect the unique characteristics of the educational context in Indonesia. It is important to continue to observe the trends and dynamics of the development of VR adoption in education so that understanding these

contradictions can help in designing more appropriate strategies to expand the use of VR at various levels of education in Indonesia.

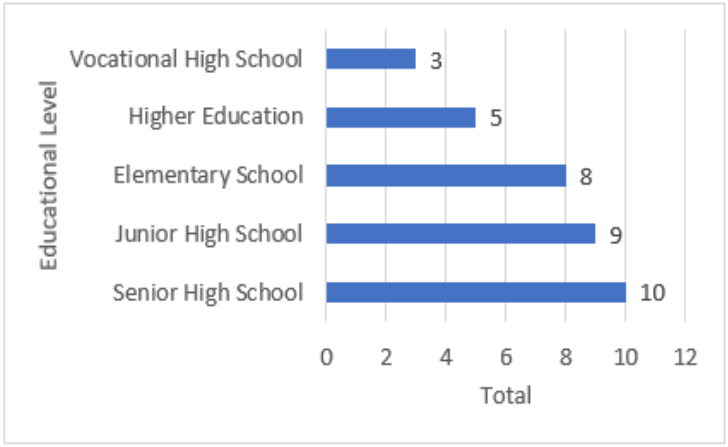

Figure 2. Educational Level

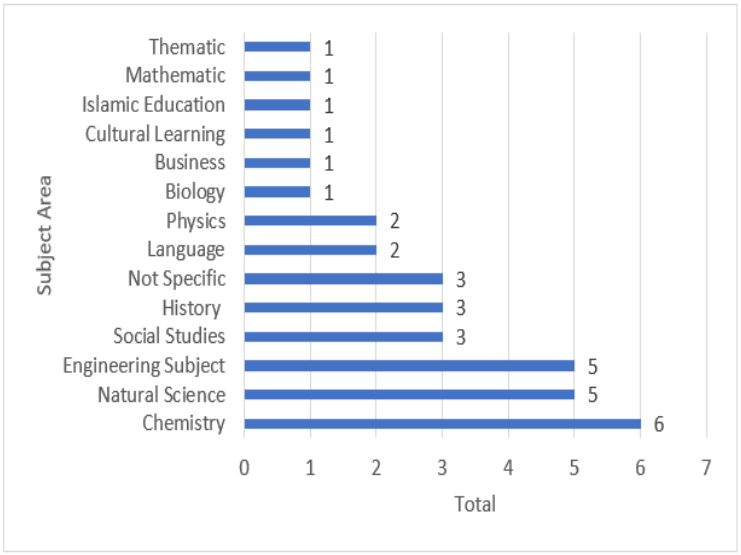

Figure 3. Subject area in implementation VR

When analyzed based on subjects, as illustrated in the data depicted in Figure 3, it becomes apparent that VR has the capability to cover a wide range of subjects and is not limited to just one area of study. However, it is an undeniable fact that the science and technology category remains the dominant area where VR is utilized, while the social-humanities group continues to be neglected and does not receive the attention it deserves. In line with this, previous research found that social science students experienced technical difficulties in using VR (Hagge, 2021). In contrast, science or technology students feel that using VR is effective as a better medium because it can represent objects in their field of study (Udeozor et al., 2021). However, students in the social group also gave a positive assessment of the use of VR, especially in increasing interest and motivation (Tarng et al., 2023). This shows that there is potential to expand the use of VR in various fields of study, thereby ensuring that all aspects of learning can be accommodated and benefit from this increasingly developing technology in the educational context in Indonesia.

HMDs Types for VR Implementation in Indonesia

Virtual Reality (VR) has undergone significant advancements over the years. Currently, the most prevalent form of VR is based on Head-mounted displays (HMDs). These devices are mounted on the user's head and generate 3D visual effects, creating an immersive simulated virtual world experience (Kamińska et al., 2019; Zhang, 2017). Before the existence of HMDs technology, the use of Virtual Reality tended to require expensive hardware and infrastructure so that it could only be used in the context of certain industries or fields with large

budgets (Jensen & Konradsen, 2018). This means that the application of VR in education is still very limited due to cost constraints and the availability of less affordable devices. HMDs lower the cost of implementing virtual reality (VR) into the classroom environment than previous-generation VR devices, but they provide an immersive experience that is not very different (Coburn et al., 2017). The presence of HMDs technology is crucial for the growth of VR's accessibility, enabling a broader and more innovative use of VR in education.

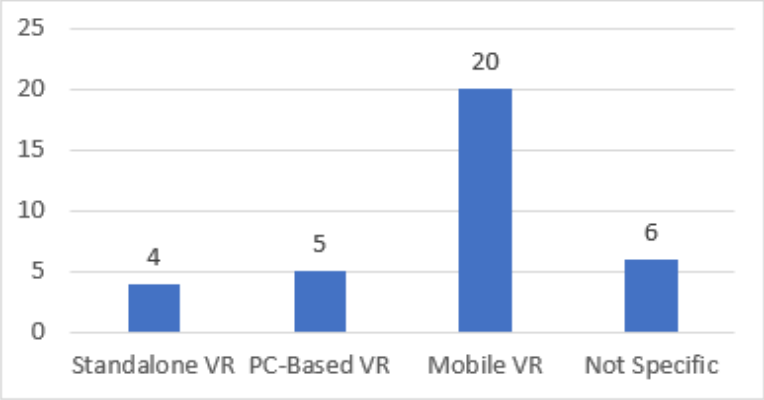

Figure 4. Trend HMDs type in Indonesia

In the application of Virtual Reality, Pallavicini et al. (2022) classify HMDs into four categories, including (1) PC-based VR, HMDs that are connected to high-specification computers; (2) Console-based VR, HMD connected to a particular game console; (3) Mobile VR, integrating smartphone with HMD; and (4) Standalone VR, the most advanced HMD device because it does not require any other attachment or is known as All-in-One HMD. In the context of the application of Virtual Reality (VR) in Indonesia, Figure 4 shows that only three types of Head-mounted displays (HMDs) technology have been used, with Mobile VR being the most dominant, namely 20 publications or the equivalent of 57% of the total use of HMDs in Indonesia. Compared with high-end HMDs (PC-based and standalone VR), mobile VR does have shortcomings in the resulting immersive environment due to limitations in processing power (Rojas-Sánchez et al., 2023). However, mobile VR is certainly not without reason the most relevant and dominant choice of HMDs used in Indonesia. Even though the visual quality is not as good as more expensive HMDs, Mobile VR is still able to provide an equally good learning experience and has a high level of accessibility because it can optimize students' smartphones (Kamińska et al., 2019; Moro et al., 2017; Papachristos et al., 2017). In other words, the advantages of more affordable costs, a high level of accessibility, and an equally good learning experience are the arguments that are most likely to make Mobile VR more dominantly accessed by schools and other educational institutions in Indonesia.

Opportunities for Implementing Virtual Reality (VR) in the Learning Process

The findings in this research illustrate various opportunities for benefits from the application of Virtual Reality (VR) to learning in Indonesia. Several publications highlight that the influence of VR tends to focus on improving one particular aspect of learning outcomes (Safitri et al., 2023; Sujarwo et al., 2023). On the other hand, there is research showing that the use of VR can have a more holistic impact, influencing several aspects of learning directly (Asriadi et al., 2023; Asril et al., 2023). Figure 5 illustrates the percentage of positive influences that emerge from the application of VR on learning in Indonesia. This data provides invaluable insights into VR's potential in transforming learning dynamics in Indonesia.

Based on Figure 5, the knowledge aspect is the most likely to have a positive impact from the application of Virtual Reality (VR) in education. This is certainly not surprising, various studies show that most students have a better ability to remember what they see in VR environments, as well as experiencing higher levels of engagement compared to traditional learning methods such as laboratory-based learning or conventional classrooms (Kamińska et al., 2019; Shen et al., 2019; Slavova & Mu, 2018). Even though the knowledge aspect plays an important role in the application of VR, it is important to recognise that the application of VR still tends to focus on the cognitive and normative aspects of learning.

The mismatch between the current application of virtual reality (VR) in Indonesia and the need of educational development is a fact that cannot be ignored. It is crucial to recognise the significance of 21st-century skills in enabling individuals to learn, work, and thrive in a rapidly changing society (Trilling & Fadel, 2009). This

reality creates a gap between the implementation of gamification in Indonesia and current educational developments, considering that 21st-century skills should be a key factor for teachers in efforts to improve the quality of teaching (Sulaiman & Ismail, 2020). Therefore, future research is expected to focus more on the application of Virtual Reality (VR) which is oriented towards developing the skills students need in the 21st century. This reality needs to receive further attention through research development because 21st-century skills are the heartbeat of teachers to improve the quality of teaching along with current educational developments.

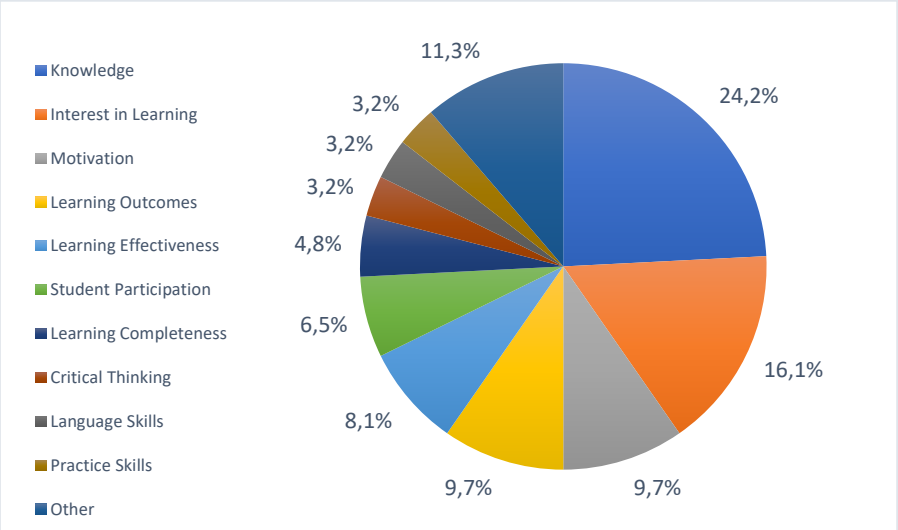

Figure 5. Positive Impact from Implementing VR

Limitations of Implementing Virtual Reality (VR) in the Learning Process

Some limitations or challenges accompany the potential benefits obtained through the implementation of virtual reality (VR) in the world of education. The main limitations that need to be considered in the implementation of virtual reality technology include a lack of understanding of user behavior in virtual environments, challenges related to technology and costs, negative impacts on health due to dependence on computer devices, and the need for adaptation to virtual environments (Coban et al., 2015). These various limitations also arise in the application of VR in Indonesia as in Figure 6. The most important issue of limitations or challenges in Indonesia is material limitations. This of course cannot be separated from creating a 3D virtual world that requires devices and applications with sophisticated specifications, quite a long time, and qualified expertise (Fanani et al., 2021; Plecher et al., 2019; Towey et al., 2018). This reality illustrates the complexity in transforming learning material into visual form. To overcome this challenge, collaboration across sectors and fields of expertise is needed to be able to present Virtual Reality (VR) that is ready to be used in learning in Indonesia.

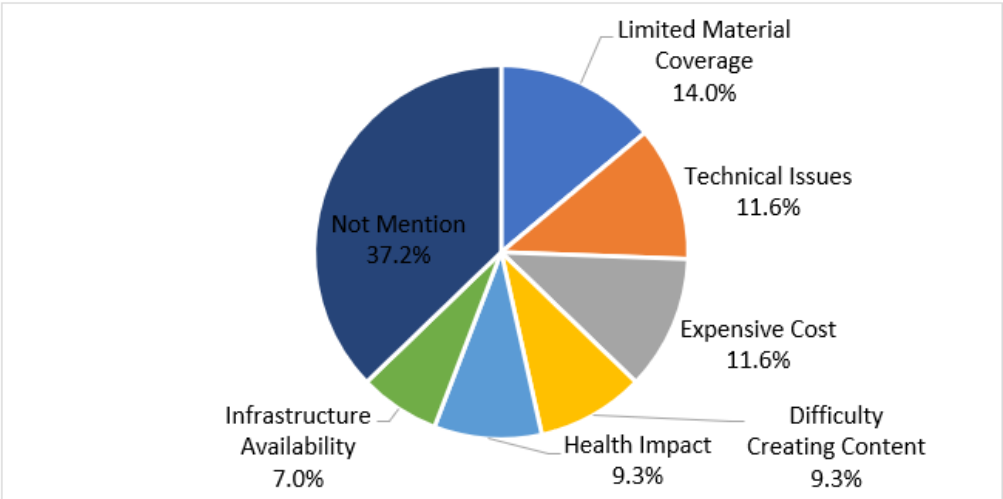

Figure 6. Limitations of implementing Virtual Reality (VR)

Apart from limitations in material and technical aspects that need to be taken into account, we must also anticipate and address any potential health impacts that may arise as VR becomes more integrated into education. Various studies in Indonesia have shown that the application of VR triggers cybersickness, which is characterized by feelings of nausea, dizziness and disorientation (Kurniawan et al., 2023; Noviana et al., 2023; Rafiq et al., 2022; Sukmawati et al., 2023). In fact, these health problems occur not only in Indonesia but also globally as a side effect of using Virtual Reality (VR) technology (Cassani et al., 2020; Chang et al., 2020; Domingo & Bradley, 2018). Therefore, teachers and students must exercise caution and use Virtual Reality (VR) technology prudently, despite its potential to enhance the quality of learning. If not used with care, VR can significantly disrupt the learning experiences of students and even pose a risk to their health.

Conclusion

The application of Virtual Reality (VR) in learning in Indonesia is a relatively new concept that has not yet received the attention it deserves. However, it is crucial to acknowledge the positive impact of implementing Virtual Reality (VR) on various aspects of the learning process and outcomes. The application of Virtual Reality (VR) is highly effective in increasing student knowledge, motivation, interest, and learning outcomes. In fact, Virtual Reality (VR) technology has the adaptive flexibility to be successfully applied in various subjects and different educational levels through the use of mobile VR-based HMDs technology. Utilizing virtual reality technology in the learning process is an imperative response to the disruptive era of the 21st century and a necessary adaptation to the characteristics of today's digital-native students. However, the implementation of VR also demands serious attention to the challenges and limitations posed by material availability, infrastructure, technical use, and potential health impacts. It is crucial to carry out further research on the implementation of VR in the educational context in Indonesia to optimize its positive impact on the learning process and ultimately contribute to improving the quality of education in Indonesia.

Recommendations

It is important to note that this research has some limitations, as it only covers data up to March 27, 2024, and relies solely on Scopus and ERIC databases. Therefore, it is highly likely that there have been significant research developments since then. To address this, future researchers may need to consider expanding the database by including additional data sources. By doing so, they can anticipate uncovering valuable insights and trends that may have emerged in the field. In substance, the information obtained in the research can be the basis for subsequent research to develop Virtual Reality (VR) in the learning context in Indonesia by expanding the application of VR to the social-humanities group subject, increasing the focus of application to vocational education which in terms of learning needs skill practice simulations, and shifts the focus of VR applications to developing the skills that individuals need in the 21st century. Besides that, It is crucial to take the initiative and create an open-source platform that can efficiently facilitate the exchange of VR content development results in learning within Indonesia. By paying attention to the limitations of existing research and implementing these development suggestions, it is hoped that further research can make a greater contribution to understanding and improving the application of VR in education in Indonesia.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

Acknowledgements or Notes

* This article was presented as an oral presentation at the International Conference on Research in Education and Social Sciences (www.icress.net) held in Tashkent/Uzbekistan on August 22-25, 2024

* We would like to express our sincere gratitude to the Indonesia Endowment Fund for Education (Lembaga Pengelola Dana Pendidikan - LPDP) for their generous support and sponsorship of this research endeavour. Their commitment to advancing education and research has played a pivotal role in the success of this research.

References

Amiati, A. (2019). The effect of virtual reality laboratory on conceptual understanding in electrolytes and non-electrolytes. *Journal of Education and Learning (EduLearn)*, *13*(3), 362–369.

Antón-Sancho, Á., Fernández-Arias, P., & Vergara, D. (2022). Assessment of virtual reality among university professors: Influence of the digital generation. *Computers*, *11*(6), 92.

Asriadi, A., Herwin, H., Shabir, A., & Dahalan, S. C. (2023). Virtual reality technology for elementary school students: A study of effectiveness in learning. *Perspektivy Nauki i Obrazovania*, *66*(6), 565–577.

Asril, Z., Syafril, S., Engkizar, & Arifin, Z. (2023). Advancing educational practices: Implementation and impact of virtual reality in Islamıc religious education. *Jurnal Pendidikan Islam*, *9*(2), 199–210.

Astuti, T. N., Sugiyarto, K. H., & Ikhsan, J. (2020). Effect of 3D visualization on students' critical thinking skills and scientific attitude in chemistry. *International Journal of Instruction*, *13*(1), 151–164.

Bakar, I. S. A., Sugiyarto, K. H., & Ikhsan, J. (2019). Effects of use 3D visualization virtual reality to increase scientific attitudes and cognitive learning achievement. *Journal of Physics: Conference Series*, *1397*(1), 012040

Buchori, A., & Osman, S. (2023). Development of virtual reality math media in the yunior high school Indonesia-Malaysia with group investigation model. *JRAMathEdu (Journal of Research and Advances in Mathematics Education)*, *8*(1), 1–11.

Cassani, R., Moinnereau, M.-A., Ivanescu, L., Rosanne, O., & Falk, T. H. (2020). Neural ınterface ınstrumented virtual reality headsets: Toward next-generation ımmersive applications. *IEEE Systems, Man, and Cybernetics Magazine*, *6*(3), 20–28.

Chang, E., Kim, H. T., & Yoo, B. (2020). Virtual reality sickness: A review of causes and measurements. *International Journal of Human–Computer Interaction*, *36*(17), 1658–1682.

Coban, M., Karakus Yılmaz, T., Karaman, A., Gunay, F., & Goktas, Y. (2015). Technical problems experienced in the transformation of virtual worlds into an education environment and coping strategies. *Educational Technology & Society*, *18*, 37–49.

Coburn, J. Q., Freeman, I., & Salmon, J. L. (2017). A review of the capabilities of current low-cost virtual reality technology and its potential to enhance the design process. *Journal of Computing and Information Science in Engineering*, *17*(3), 4036921.

Domingo, J. R., & Bradley, E. G. (2018). Education student perceptions of virtual reality as a learning tool. *Journal of Educational Technology Systems*, *46*(3), 329–342.

Elaoufy, H. (2023). Bridging the gap between digital native students and digital ımmigrant professors: Reciprocal learning and current challenges. *American Journal of Education and Technology*, *2*(2), 23–33.

Elmira, U., Abay, D., Shaimahanovna, D. A., Erzhenbaikyzy, M. A., Aigul, A., & Rabikha, K. (2022). The importance of game technology in primary education. *World Journal on Educational Technology: Current Issues*, *14*(4), 996–1004.

Ernawati, D., & Ikhsan, J. (2021). Fostering students' cognitive achievement through employing virtual reality laboratory (VRL). *International Journal of Online and Biomedical Engineering*, *17*(13), 44–58.

Fanani, A. Z., Hastuti, K., Syarif, A. M., & Harsanto, P. W. (2021). Challenges in developing virtual reality, augmented reality and mixed-reality applications: Case studies on a 3D-based tangible cultural heritage conservation. *International Journal of Advanced Computer Science and Applications*, *12*(11).

Habibah, A., Pujiarti, D. A., Widyanti, A., & Soetisna, H. R. (2021). The potential and challenges of virtual reality in Indonesia. *Proceedings of the Second Asia Pacific International Conference on Industrial Engineering and Operations Management*, *2027,* 2811-2819.

Hagge, P. (2021). Student perceptions of semester-long ın-class virtual reality: Effectively using "Google Earth VR" in a higher education classroom. *Journal of Geography in Higher Education*, *45*(3), 342–360.

Hasanudin, M., Arribathi, A. H., Indrianto, Yuliana, K., & Kristiadi, D. P. (2021). Increasing ındependence of cerebral palsy children using virtual reality based on Mlearning. *Journal of Physics: Conference Series*, *1764*(1), 012119.

Herwin, H., Shabir, A., & Asriadi, A. (2022). Learning management system based on virtual reality technology in elementary school. *World Journal on Educational Technology: Current Issues*, *14*(5), 1504–1515.

Iasha, V., Japar, M., Maksum, A., & Setiawan, B. (2023). Let's go on a virtual reality trip!: The effect on the students' literacy, ınterest, and satisfaction in cultural learning. *TEM Journal*, *12*(4), 2488–2499.

Ikhsan, J., Sugiyarto, K. H., & Astuti, T. N. (2020). Fostering student's critical thinking through a virtual reality laboratory. *International Journal of Interactive Mobile Technologies*, *14*(8), 183–195.

Jensen, L., & Konradsen, F. (2018). A review of the use of virtual reality head-mounted displays in education and training. *Education and Information Technologies*, *23*(4), 1515–1529.

Juhana, A., Yusuf, R., Prihatmanto, A. S., & Abdullah, A. G. (2020). Basic electrical installation trainer boards: Virtual reality based laboratory for electrical basic education. *2020 6th international conference on interactive digital media (ICIDM)* (pp. 1-6). IEEE.

Kamińska, D., Sapiński, T., Wiak, S., Tikk, T., Haamer, R., Avots, E., Helmi, A., Ozcinar, C., & Anbarjafari, G. (2019). Virtual reality and ıts applications in education: Survey. *Information*, *10*(10), 318.

Kurniawan, Y., Susandyoga, A. E., Kamal, I. A., Sismandrajaya, R., Hiererra, S. E., & Bhutkar, G. (2023). Analysis of readiness to use the metaverse platform in learning activities. *Emerging Science Journal*, *7*(6), 2133–2155.

Kurniawati, A., Abdullah, F. F., Agustiono, W., Warninda, S. S., & Kusumaningsih, A. (2020). Introduction virtual reality for learning media in schools in Indonesia. *Journal of Physics: Conference Series*, *1569*(2).

Maulana, F. I., & Purnomo, A. (2021). Development of virtual reality application to ıncrease student learning motivation with ınteractive learning in vocational education. *IOP Conference Series: Materials Science and Engineering*, *1071*(1), 012019.

McFaul, H., & FitzGerald, E. (2020). A realist evaluation of student use of a virtual reality smartphone application in undergraduate legal education. *British Journal of Educational Technology*, *51*(2), 572–589.

McGovern, E., Moreira, G., & Luna-Nevarez, C. (2020). An application of virtual reality in education: Can this technology enhance the quality of students' learning experience? *Journal of Education for Business*, *95*(7), 490–496.

Monita, F. A., & Ikhsan, J. (2020). Development virtual reality IPA (VR-IPA) learning media for science learning. *Journal of Physics: Conference Series*, *1440*(1), 012103

Moro, C., Štromberga, Z., & Stirling, A. (2017). Virtualisation devices for student learning: Comparison between desktop-based (Oculus Rift) and mobile-based (Gear VR) virtual reality in medical and health science education. *Australasian Journal of Educational Technology*, *33*(6).

Neelakantam, S., & Pant, T. (2017). *Learning web-based virtual reality: build and deploy web-based virtual reality technology*. Apress.

Noviana, E., Plank, U., & Wand, E. (2023). Museum Maya Indonesia: An immersive museum prototype for cultural education. *SHS Web of Conferences*, *189*, 01021.

Nurhadi, J., Rahma, R., & Fadlilah, A. (2019). Multimedia based on virtual reality in Indonesian for foreign speakers learning. *Journal of Physics: Conference Series*, *1179*(1). https://doi.org/10.1088/1742-6596/1179/1/012118

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Systematic Reviews*, *10*(1), 89.

Pallavicini, F., Pepe, A., Clerici, M., & Mantovani, F. (2022). virtual reality applications in medicine during the covıd-19 pandemic: Systematic review. *JMIR Serious Games*, *10*(4), e35000.

Papachristos, N. M., Vrellis, I., & Mikropoulos, T. A. (2017). A comparison between oculus rift and a low-cost smartphone VR headset: Immersive user experience and learning. *2017 IEEE 17th International Conference on Advanced Learning Technologies (ICALT)*, 477–481.

Plecher, D. A., Wandinger, M., & Klinker, G. (2019). Mixed reality for cultural heritage. *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, 1618–1622.

Prensky, M. (2001). Digital natives, digital ımmigrants part 1. *On the Horizon*, *9*(5), 1–6.

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, *147*, 103778.

Rafiq, A. A., Triyono, M. B., & Djatmiko, I. W. (2022). Enhancing student engagement in vocational education by using virtual reality. *Waikato Journal of Education*, *27*(3), 175–188.

Rahayu, S., Usman, H., Sugito, S., & Herwin, H. (2022). The digital module encourages expression to develop the social competence of early childhood education teachers. *World Journal on Educational Technology: Current Issues*, *14*(3), 682–691.

Ramansyah, W., Aini, N., Fitriansyah, W., & Pratama, M. Di. (2021). Virtual reality and educational game to learn madurese history and alphabet for elementary school students. *Journal of Physics: Conference Series*, *1842*(1), 012012.

Rohayati, N., Hodiyah, I., & Marwan, I. (2022). Development of three-dimensional virtual reality technology for learning languages in Pencak Silat curriculum. *Eurasian Journal of Applied Linguistics*, *8*(2), 283–290.

Rojas-Sánchez, M. A., Palos-Sánchez, P. R., & Folgado-Fernández, J. A. (2023). Systematic literature review and bibliometric analysis on virtual reality and education. *Education and Information Technologies*, *28*(1), 155–192.

Safitri, D., Sujarwo, Marini, A., Fitrisia, A., Sudarmiani, Widodo, S., & Meyers, K. F. (2023). Model of virtual reality in social studies to ımprove student learning outcomes. *Eurasian Journal of Educational Research*, *2023*(105), 103–118.

Saputro, S. D., & Setyawan, A. (2020). The effectiveness use of virtual reality media in physics education of solar system towards cognitive learning outcomes. *JPI (Jurnal Pendidikan Indonesia)*, *9*(3), 389.

Sartono, E. K. E., Sekarwangi, T., & Herwin, H. (2022). Interactive multimedia based on cultural diversity to improve the understanding of civic concepts and learning motivation. *World Journal on Educational Technology: Current Issues*, *14*(2), 356–368.

Senadheera, V. V., Rupasinghe, T. P., & Ediriweera, D. S. (2024). 'Connective alignment' as the educational approach for higher education in the digital age. *Journal of Learning for Development*, *11*(1), 172–180.

Setyowati, R. R., Rochmat, S., Aman, & Nugroho, A. N. P. (2023). Virtual reality on contextual learning during covid-19 to ımprove students' learning outcomes and participation. *International Journal of Instruction*, *16*(1), 173–190.

Shen, H., Zhang, J., Yang, B., & Jia, B. (2019). Development of an educational virtual reality training system for marine engineers. *Computer Applications in Engineering Education*, *27*(3), 580–602.

Shepa, M. J., Serevina, V., & Astra, I. M. (2021). Development of virtual reality-based learning media on electromagnetic wave radiation material. *Journal of Physics: Conference Series*, *1876*(1), 012088

Sholihin, M., Sari, R. C., Yuniarti, N., & Ilyana, S. (2020). A new way of teaching business ethics: The evaluation of virtual reality-based learning media. *International Journal of Management Education*, *18*(3), 100428.

Slavova, Y., & Mu, M. (2018, March). A comparative study of the learning outcomes and experience of VR in education. In *2018 IEEE conference on virtual reality and 3D user interfaces (VR)* (pp. 685-686). IEEE.

Soenarto, S., Khairudin, M., Triatmaja, A. K., & Azman, M. N. A. (2023). Improving competence through virtual digital engineering laboratories with mobile virtual reality. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *31*(2), 157–172.

Suh, A., & Prophet, J. (2018). The state of immersive technology research: A literature analysis. *Computers in Human Behavior*, *86*, 77–90.

Sujarwo, Japar, M., Sumantri, M. S., Safitri, D., & Marini, A. (2023). Enhancement of students' learning outcomes through virtual reality based on case-based learning in social studies. *Eurasian Journal of Educational Research*, *2023*(106), 171–191.

Sukaridhoto, S., Fajrianti, E. D., Haz, A. L., Budiarti, R. P. N., & Agustien, L. (2023). Implementation of virtual fiber optic module using virtual reality for vocational students. *JOIV : International Journal on Informatics Visualization*, *7*(2), 356.

Sukmawati, F., Santosa, E. B., & Rejekiningsih, T. (2023). Design of virtual reality zoos through ınternet of things (IoT) for student learning about wild animals. *Revue d'Intelligence Artificielle*, *37*(2), 483–492.

Sulaiman, J., & Ismail, S. N. (2020). Teacher competence and 21st century skills in transformation schools 2025 (TS25). *Universal Journal of Educational Research*, *8*(8), 3536–3544.

Suleman, M., Sugiyarto, K. H., & Ikhsan, J. (2019). Development of media three-dimensional (3d) visualization using virtual reality on chemistry education. *Journal of Physics: Conference Series*, *1397*(1), 012034

Sulisworo, D., Erviana, V. Y., Robiin, B., Sepriansyah, Y., & Soleh, A. (2022). The feasibility of enhancing environmental awareness using virtual reality 3d in the primary education. *Genetics Research*, *2022*(1), 4811544

Tarng, W., Su, Y.-C., & Ou, K.-L. (2023). Development of a virtual reality memory maze learning system for application in social science education. *Systems*, *11*(11), 545.

Towey, D., Walker, J., Austin, C., Kwong, C.-F., & Wei, S. (2018). Developing virtual reality open educational resources in a Sino-Foreign Higher Education Institution: Challenges and strategies. *2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, 416–422.

Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times*. John Wiley & Sons.

Turner, A. (2015). Generation Z: Technology and social ınterest. *The Journal of Individual Psychology*, *71*(2), 103–113.

Udeozor, C., Toyoda, R., Russo Abegão, F., & Glassey, J. (2021). Perceptions of the use of virtual reality games for chemical engineering education and professional training. *Higher Education Pedagogies*, *6*(1), 175–194.

Widiyatmoko, A., Nugrahani, R., Yanitama, A., & Darmawan, M. S. (2023). The effect of vırtual realıty game-based learnıng to enhance Stem lıteracy in energy concepts. *Jurnal Pendidikan IPA Indonesia*, *12*(4), 648–657.

Zhang, H. (2017). Head-mounted display-based intuitive virtual reality training system for the mining industry. *International Journal of Mining Science and Technology*, *27*(4), 717–722.

Zikky, Moh., Fathoni, K., & Firdaus, M. (2018). Interactive distance media learning collaborative based on virtual reality with solar system subject. *2018 19th IEEE/ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD)*, 4–9.

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To cite this article:

Dwiputra, D.F.K., Maryani, E., Susanti, S. (2024). From limitations to opportunities: A systematic literature review of application virtual reality. *The Eurasia Proceedings of Educational and Social Sciences (EPESS), 36,* 12-24.