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Bibliometric Analysis of the Trend of Virtual Reality Use in Physics Learning: Focusing on the Kuula Platform and Its Impact on the Learning Outcomes of Fluid Material

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Abstract

Background of Study: Fluid material in physics is often difficult to understand due to its abstract nature and the need for dynamic visualization. VR technology is considered capable of providing an immersive and interactive learning experience, thereby supporting student understanding and engagement more effectively.
Aims and Scope of Paper: This research aims to analyze the potential development of VR(Virtual Reality) based learning media in physics education, focusing on the use of the Kuula platform to improve student learning outcomes on fluid material in 11th-grade high school.
Methods: In this study, a bibliometric analysis was conducted to explore publication trends and scientific findings related to the application of VR in physics learning, especially those relevant to the Kuula platform and fluid topics. Data were obtained from 145 Scopus-indexed articles from 2020 to 2025 and analyzed using software Biblioshiny and VOSviewer.
Result: The analysis shows an increase in publications related to VR in education, with a primary focus on enhancing student engagement, learning motivation, and understanding of abstract concepts. Bibliometric visualization indicates a strong connection between VR and the fields of education, technology, and health, with China and the United States emerging as dominant contributors. However, the decline in average citations per article suggests the need to improve the quality and depth of research in this area.
Conclusion: Overall, these findings affirm that VR-based physics learning media have significant potential in improving student learning outcomes on fluid topics, as well as highlighting the importance of developing a curriculum responsive to advancements in educational technology.

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INTRODUCTION

The development of information and communication technology (ICT) in the era of the Industrial Revolution 4.0 has brought significant and transformational impacts in various sectors, especially in the field of education. The Industrial Revolution 4.0 is characterized by rapid technological advancements, including digitalization, automation, and the utilization of the Internet of Things (IoT)(Dito & Pujiastuti, 2021;Suhaidi et al., 2023).This technology is not only changing the way we interact with information, but it is also changing the overall teaching and learning methods. With digitalization, education can utilize various forms of learning media that are more interactive and interesting, such as digital libraries, audio-visual learning materials, and e-learning platforms that support students in the teaching and learning(Widiyanto, 2023 ; Erisa et al., 2023;Dito & Pujiastuti, 2021). In Indonesia, the use of the internet and ICT has increased significantly, which provides wider access to digital learning resources and interactive learning platforms for students and educators (Putra et al., 2022). However, the biggest challenge facing today is the digital divide between those who can access technology and those who cannot, as well as how to use it productively in the context

of education. This requires educators to not only integrate technology into the curriculum but also to shape students' character and skills to be ready to face the demands of the digital era(Putra et al., 2022). Advances in ICT create opportunities for the development of a curriculum that is more responsive to the needs of industry and society, known as education 4.0. This demands a merger between technology-based learning and critical skills development, digital literacy, and creativity (Putriani & Hudaidah, 2021). In addition, the use of educational applications and project-based learning tools allows students to interact better and gain a deeper understanding of the material being taught, resulting in a more active and productive learning process (Ratri et al., 2023). The challenges and demands of 21st century learning, known as the 4Cs (Critical Thinking, Creativity, Collaboration, Communication), are crucial in today's educational context. With the rapid development of information and communication technology and the demands of globalization, education needs to adapt to prepare future generations who are ready to face various changes and challenges. Learning that focuses on developing 21st century skills is expected to equip students with relevant competencies and be able to contribute to an increasingly complex society (Purwanti et al., 2022). Critical thinking skills are one of the main competencies that are expected to be developed in 21st century learning. Education should stimulate students' ability to analyze information, make evidence-based decisions, and solve problems in an analytical and structured way (Sulistyaningrum et al., 2024). In addition to critical thinking, creativity is also an inseparable element in 21st century education. Students are required to not only absorb information, but also create and innovate, both in academic contexts and in solving real problems faced in society (Jannah & Atmojo, 2022). To achieve this, the use of digital media and technology in learning activities provides a platform that allows students to experiment and innovate. For example, the application of interactive media can encourage students to think outside of traditional boundaries and explore their potential in new ways. Physics as a conceptual and abstract subject has a unique nature in terms of its learning and teaching. Physics not only involves understanding theories but also requires the ability to apply those principles in real-world situations. In the context of education, it is important to realize that the success of physics learning is greatly influenced by the motivational climate created in the classroom. A positive motivational climate can encourage faster and more effective learning, while a negative climate can actually hinder students' learning processes (González Valero et al., 2022). Students' active involvement in learning, which is often recognized as key in teaching methodologies, also supports the understanding of abstract concepts offered in physics, which are often considered complicated by many students (Bravo & Asan, 2023). Fluid materials in education, especially at the secondary school level, require a high spatial and visual understanding in order for students to understand complex concepts. Given that many students face difficulties with fluid dynamic materials, research shows that the use of visual media can be very effective in improving their understanding. According to (Misbah et al., 2023). It was stated that the application of educational games in physics learning about dynamic fluids can significantly improve students' problem-solving skills. This is supported by (Rahmawati et al., 2023). which emphasizes the need for practicum tools that can describe the distribution and volume of water, which is an important component in understanding dynamic fluid materials. The importance of visualization in education is also confirmed by research showing that the use of interactive video and animation is helpful in conveying and explaining difficult concepts (Addriani et al., 2023;Penyustia, 2023). By using interactive multimedia, students can gain a better understanding of the properties and behaviors of fluids in a variety of contexts, which are essential for improving their spatial senses and visual abilities. In addition, Suri et al. emphasize that the use of e-comics as a learning medium can facilitate the understanding of the concept of static fluids in a more interesting way (Suri et al., 2021). Low student learning outcomes in fluid materials is a complex problem and can be influenced by various factors. Internal factors such as learning motivation, interest, and students' basic understanding of the material play a very important role in determining the final learning outcome. Research shows that students who are highly motivated tend to have better learning outcomes (Destina et al., 2021). In addition, a basic understanding of physical concepts, including fluids, is also an important pillar. Students who do not have a strong foundation of understanding will have difficulty understanding and applying more complex material (Insani et al., 2023). External factors also have a significant influence on student learning outcomes. A conducive learning environment, including support from teachers and school facilities, contributes to the effectiveness of the educational process. A study

shows that a conducive environment and appropriate learning methods can improve student learning outcomes (Destina et al., 2021;Ekawati, 2022). Teachers' inability to apply the right methods can result in low learning outcomes, as revealed in research that shows that choosing the wrong learning method can hinder students' understanding of the subject matter (Surianti et al., 2023). The trend of implementing Virtual Reality (VR) in education, both at the national and global levels, has gained increasing attention in recent years. This is in line with the evolution of educational technology that encourages institutions to integrate modern tools in the learning process. In the context of Indonesia's national education, the use of information and communication technology, including VR, is one of the priorities in improving the quality of education and expanding access to learning in all corners of the country (Rezeki & Susanti, 2023). One of the important aspects of the use of VR in education is its ability to create immersive learning experiences. Through VR, students can engage in immersive simulations and interactions that cannot be achieved with conventional methods. The use of VR creates opportunities for students to understand complex concepts in a more intuitive way, stimulating higher emotional and cognitive engagement compared to traditional learning (Sulkipani et al., 2023). The application of virtual reality (VR) technology in education, particularly in the context of increasing student engagement, motivation, and learning outcomes, has received significant attention in recent years. Various studies show that the use of VR in education not only provides an immersive learning experience but also has a positive impact on students' academic outcomes. One of the important aspects of VR is its ability to increase student engagement. In the context of medical education, according to (Mustikasari et al., 2024;Fitrianto & Saif, 2024). explains how VR can improve the practice of learning anatomy and physiology in physiotherapy majors. Their research shows that students who use VR in the learning process have better test scores compared to those who use traditional learning methods. This shows that VR not only makes learning more engaging but also helps students understand complex concepts better. In addition, VR has also been shown to increase students' motivation to learn. Research shows that the interactive experiences offered by VR can increase students' interest in learning. This method allows students to be actively involved in the learning process, which often leads to increased intrinsic motivation. By providing a hands-on and realistic experience, VR can help students feel more connected to the material being studied, encouraging them to be more engaged in learning. In terms of learning outcomes, a meta-analysis by several researchers showed that learning using VR can result in higher scores in academic evaluations than conventional learning methods. The test scores of students engaged in VR-based learning showed a significant improvement, demonstrating the effectiveness of VR in achieving better academic outcomes (Mustikasari et al., 2024).

Based on the descriptions that have been submitted, this study intends to examine the problems that occur by developing virtual reality. Therefore, a research will be conducted with the title "Development of virtual reality-based learning media assisted by the Kuula platform on fluid materials to improve the learning outcomes of high school students in grade XI".

METHOD

In this study entitled "Bibliometric analysis of the trend of using virtual reality in physics learning: focusing on the kuula platform and its impact on fluid material learning outcomes", data was collected using seven main keywords. All data is taken from the Scopus database and has gone through a filtering process with a range of years of publication between 2020 to 2025. This time range was chosen because of the difficulty of finding the latest articles relevant to the research topic. The keywords used in the search are divided into several combinations. The first to third keywords relate to terms such as "virtual reality" AND "physics education", "virtual reality" AND "learning outcomes", "virtual reality in Education". The fourth to fifth keywords are aimed at finding articles that discuss media in physics learning as well as the application of AI in learning, using keywords such as "Media" AND "physics education", "physics education" AND "artificial intelligence". Meanwhile, the sixth and seventh keywords are used to explore physics material (fluid) in the application of VR media, by using keywords such as "fluid" AND "physics education", and "virtual reality" AND "fluid" After using these keywords we will get the number of articles we want https://www.files2zip.com/. Furthermore, the merged CSV file is processed using the OpenRefine application. This application is used to clean data from duplicates as well as biased articles. After the

cleaning process is complete, the number of valid and ready articles is analyzed. The next stage is the process of interpreting bibliometric data using the Biblioshiny application. Through this application, various important information is obtained such as keyword metadata, key information on data sheets, graphs and growth tables of articles per year, graphs and tables of citations per year, Three-Field Plot diagrams, list of the most relevant sources, local impact of sources, core sources based on Bradford's Law, cumulative frequency of occurrences, production of authors over time, distribution of correspondent authors by country, as well as graphs and tables related to the scientific contributions of countries in the field. Next, the data is visualized using the VOSviewer application, which displays relationships between articles, authors, and topics in the form of Overlay Visualization and Network Visualization. This visualization is very helpful in understanding the patterns of linkages in the literature analyzed.

Figures And Tables

Table 1 is the Number of Document Search Results Based on Keywords

Table 1. The Number of Document Search Results Based on Keywords

No	Keywords	Initial Amount	Quantity After Filter
1	"virtual reality" AND "physics education"	81	—
2	"virtual reality" AND "learning outcomes"	31	9
3	"virtual reality in education"	2	—
	Subtotal 1: Virtual Reality and Education	**116**	**92**
4	"Media" AND "physics education"	38	33
5	"physics education" AND "artificial intelligence"	15	10
	Subtotal 2: Media and AI in Physics	**43**	**43**
6	"fluid" AND "physics education"	12	8
7	"virtual reality" AND "fluid"	29	12
	Subtotal 3: Virtual Reality and Fluid Matter	**41**	**20**
	Total	**200**	**155**
	After Duplicates Removed (OpenRefine)	**—**	**145 Items Valid**

Figure 1 is a picture of the bibliometrix analysis flow.

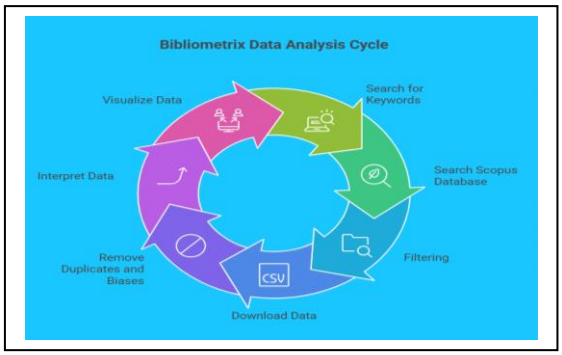

Figure 1. Bibliometric Analysis Flow

RESULTS AND DISCUSSION

Results

The results of the analysis show that the use of VR, especially through the Kuula platform, has great potential to improve the understanding of abstract fluid concepts in physics learning. The increasing number of international publications and collaborations indicates an increase in interest and attention to this topic. However, the decline in the average citation is a warning that the quality and contribution of science must be maintained despite the increase in the quantity of publications. Analysis of keywords and literature networks shows that VR topics in education are not only related to science learning, but also to health technologies and human-computer interfaces. This opens up wider cross-field development opportunities.

Discussion

1. **Implications**

   The main implication of these results is that the application of VR in physics education can create a more immersive and engaging learning experience, especially on abstract materials such as fluids. For teachers and educational institutions, these results serve as a basis for considering integrating VR technology in the curriculum as a strategy to improve student learning outcomes and digital literacy in the 21st century.

2. **Research contribution**

   This research contributes in the form of a systematic mapping of the scientific literature related to the use of VR in physics learning. Through a bibliometric approach, this study succeeded in identifying trend directions, scientific collaboration, as well as relevant key sources. This is a strong foundation for the development of proven and directed VR-based learning media, especially on the use of the Kuula platform.

3. **Limitations**

   The study has some limitations, such as using only data from the Scopus database, which could exclude important articles from other databases. In addition, the 2020–2025 timeframe may not adequately cover all the current dynamics, especially for 2025 which is still ongoing. Another limitation is that no direct experimental tests have been conducted on the effectiveness of Kuula in real classes.

4. **Suggestions**

   Further research is suggested to conduct a direct trial of the use of Kuula in physics classrooms to measure its effectiveness on student learning outcomes. In addition, the expansion of the analysis to other databases such as the Web of Science or Google Scholar is also recommended to obtain a wider coverage of the literature. Researchers can also explore the potential for cross-disciplinary collaboration, for example between education, technology, and health, to develop adaptive and innovative VR media.

CONCLUSION

Based on the results of the bibliometric study in this study, it can be concluded that the application of virtual reality (VR)-based learning media, especially with the help of the Kuula platform, has significant potential in improving student learning outcomes in fluid materials at the high school level. An analysis of 145 scientific articles from the Scopus database in the 2020–2025 period shows that the use of VR in education is growing rapidly, with a focus on increasing student engagement, learning motivation, and understanding of abstract concepts such as fluids. Keyword network visualization reveals that the topic of virtual reality is closely related to the fields of education, technology, and health, and shows a high level of collaboration between countries and between authors. Despite the increasing trend in the number of publications, the average citations per article has decreased, which is a reminder of the importance of maintaining the quality of research amid the growth in quantity.

The main contribution of this research to science in the future is to provide a strong foundation for the development of innovative learning models based on immersive technology, especially in science learning such as physics. The results of these findings can be a reference for the development of technology-based curriculum that is more adaptive to the learning needs of the 21st century. In addition, the bibliometric approach used in this study provides a comprehensive overview of the trends, directions, and gaps of research that are still open, so that it can help future researchers in designing more targeted and impactful studies. Thus, this research not only provides a solution to the low student learning outcomes in fluid materials, but also encourages the advancement of the use of evidence-based and collaborative educational technology in the future.

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AUTHOR CONTRIBUTION STATEMENT

RA contributed to the conceptualization of the research, data collection, bibliometric analysis using Biblioshiny and VOSviewer, as well as the interpretation of results. ER also wrote, edited, and BG finalized the manuscript for publication.

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