

# Advantages and Disadvantages of Virtual Reality in Science Learning Systems in the 21<sup>st</sup> Century: A Review

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**Abstract:** The rapid development of information technology has brought human civilization into the 21<sup>st</sup> century, which requires mastery of 21<sup>st</sup>-century skills, such as critical, creative, collaborative, and communicative thinking. Virtual reality offers an immersive and interactive learning experience, allowing students to interact with virtual environments as if they were real, thus potentially increasing conceptual understanding and learning motivation. Virtual reality has advantages and disadvantages in science learning. Where the purpose of the study is to examine the advantages and disadvantages of virtual reality in science learning systems in the 21<sup>st</sup> century: a Review, namely collecting information from previous studies related to the Advantages and Disadvantages of Virtual Reality in Science Learning Systems in the 21<sup>st</sup> Century This review was conducted based on the review method. The results of this study explain that there are several advantages and disadvantages of using a science learning system that uses virtual reality, one of the results that explains the advantages of virtual reality is Immersive Learning so that students can see learning concepts more realistically and not only focus on books or material explanations; teachers and one of the disadvantages of virtual reality in science learning is that VR systems can be expensive to develop and maintain, making them less accessible to organizations, educational institutions with limited budgets.

**Keywords:** Science learning; Virtual reality; 21<sup>st</sup> century

## Introduction

The rapid development of information technology has brought human civilization into the 21<sup>st</sup> century, marked by the era of the Industrial Revolution 4.0 and continuing to Society 5.0. The Industrial Revolution 4.0 emphasizes automation and digitalization in various industrial sectors, while Society 5.0 focuses on the use of technology to solve social problems and improve the quality of human life (Raja Santhi & Muthuswamy, 2023; Ghobakhloo et al., 2024). In this era, 21<sup>st</sup> century skills, such as critical, creative, collaborative, and communicative thinking, are very important

(Herlinawati et al., 2024; Thornhill-Miller et al., 2023). Education plays a crucial role in preparing competent human resources to face global challenges. 21<sup>st</sup> century education requires students to have high cognitive abilities to be able to adapt and compete in the digital era (Van Laar et al., 2020; Wrahatnolo & Munoto, 2018). Science learning is essentially related to how to find out about nature systematically so science is certainly not only the mastery of a collection of knowledge in the form of facts, concepts, or principles but also a process of discovery. The science learning process emphasizes providing direct experience to develop competencies to explore and understand the natural environment

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scientifically. Science education is directed at finding out and doing so that it can help students gain a deeper understanding of the natural environment. At the school level, science learning is carried out in an integrated manner (Thana et al., 2022; Muhaimin et al., 2020; Refmidawati, 2023).

Science learning emphasizes the principle of scientific inquiry, which is the process of finding out why something happens using scientific methods (Yaqub & Alsabban, 2023). This process involves three scientific components, namely the scientific method (systematic steps in research), scientific attitudes (such as curiosity, accuracy, and objectivity), and scientific products (in the form of facts, concepts, laws, and theories). Through scientific inquiry, students are trained to think critically, and analytically, and solve problems, which are important for the development of their cognitive abilities (Kustijono & Hakim, 2020). However, science learning often faces challenges, especially in visualizing abstract concepts that are difficult for students to understand (Darling-Hammond et al., 2020; Pei et al., 2024; Haleem et al., 2022). Natural Sciences (IPA) have an important role in developing students' cognitive abilities but are often faced with challenges, such as students' difficulty in visualizing abstract concepts and lack of motivation to learn (mention references). These difficulties can hinder a deep understanding of natural phenomena. To overcome these challenges, innovation in science learning is needed, one of which is by utilizing virtual reality technology (Maroukgas et al., 2023).

Virtual reality offers an immersive and interactive learning experience, allowing students to interact with virtual environments as if they were real, thus potentially increasing conceptual understanding and learning motivation. Virtual reality has advantages and disadvantages in science learning. Although research on the application of virtual reality in education has been widely conducted Publication performance and trends in virtual reality research in education fields: a bibliometric analysis (Elaiash et al., 2024; Wei, 2019) Research progress on Virtual Reality (VR) and Augmented Reality (AR) in tourism and hospitality research that specifically examines the advantages and disadvantages of virtual reality in science learning systems in the 21<sup>st</sup> century is still limited. Therefore, this study aims to examine the advantages and disadvantages of virtual reality in science learning systems in the 21<sup>st</sup> century."

## Method

This study uses a review method. The framework is designed to classify data sources and general

information studied in the study. The author attempts to collect information from previous studies related to the variables. The full article is published in the 2015-2023 international journal, indexed in the database, and themed the advantages and disadvantages of virtual reality in the science learning system in the 21<sup>st</sup> century; a review.

## Result and Discussion

Implementation of Science Literacy to Improve Science Learning Guidance from teachers to students is a concept and process contained in the implementation. Teachers as facilitators must be able to encourage students to think at a high level to create science literacy (Assen & Otting, 2022). The teacher's teaching method must be changed to improve the quality of students' science literacy. Teachers must create learning that is related to everyday life (Silseth & Erstad, 2022). So that students can apply their understanding directly. Connecting science literacy to the science learning process can be a solution to providing science literacy (Bramastia & Rahayu, 2023; Suroso et al., 2021). Learning activities can be carried out through science experiments because science learning is contextual (Sekarini & Arty, 2019; Kurniasari et al., 2018). Therefore, students can apply and observe objects directly and get real experiential learning. Science learning through investigation to explain natural phenomena that are occurring until conclusions are drawn (Speldewinde et al., 2024; Herman et al., 2019).

According to Lestari et al. (2021), scientific literacy can support students to analyze surrounding problems and think critically about natural phenomena. There are 5 dimensions for the application of scientific literacy carried out by teachers, namely understanding the basics of science, learning content based on scientific literacy, learning processes based on scientific literacy, evaluation of learning based on scientific literacy, attitudes towards learning based on scientific literacy (Bórquez-Sánchez, 2024). Virtual Reality (VR) is a technology that creates an immersive and interactive computer-simulated environment, allowing users to feel the presence and interact with virtual objects and environments as if they were real. This technology has been applied in various fields, including entertainment, medicine, and education. In education, VR offers great potential to create more engaging and effective learning experiences, especially in science learning. One of the main challenges in science learning is students' difficulty in visualizing abstract concepts, such as molecular structure, the solar system, or human anatomy.

VR can overcome this challenge by providing interactive and immersive 3D visualizations, allowing

students to "explore" molecules, "fly" between planets, or "dissect" human organs virtually. The main goal of VR is to create an experience that makes users feel immersed in a simulated three-dimensional (3D) environment (Hamad & Jia, 2022). To achieve this immersion, VR systems use 3D graphics and sound displayed through hardware such as glasses or electronic gloves. Interactivity is another important aspect, allowing users to interact with virtual objects and environments in real-time. Thus, VR seeks to provide a shared 3D experience between humans and computers, where users can experience artificially generated environments as if they were real. Virtual reality has advantages and disadvantages in the 21<sup>st</sup> century science learning system. Figure 1 shows the relationship between the interface of the method of creating a virtual world and aspects of the user's personality. All of these elements affect the virtual reality experience and presence. Virtual reality systems allow for the exchange of information with the virtual environment. Information is exchanged through an interface to the virtual world. The user interface is the gateway between the user and the virtual environment. Ideally, the gateway will allow transparent communication and information transfer between the user and the virtual environment. The user interface defines how the user communicates with the virtual world and how the virtual world manifests clearly.

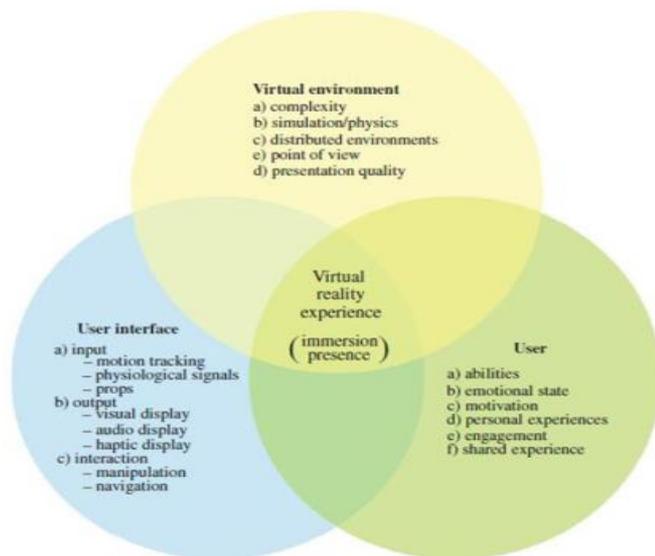


Figure 1. Virtual reality integration

Virtual reality systems allow for the exchange of information with the virtual environment. Information is exchanged through an interface to the virtual world. The user interface is the gateway between the user and the virtual environment. Ideally, the gateway will allow for transparent communication and information transfer between the user and the virtual environment. The user

interface defines how the user communicates with the virtual world and how the virtual world manifests clearly. user, the method of creating the virtual world, and aspects of the user's personality. All of these elements affect the virtual reality experience and presence.

*Advantages of Virtual Reality in Science Learning and Other Interests*

*Immersive Learning*

VR provides an immersive and realistic learning experience, allowing users to interact with virtual environments and objects as if they were real (Holuša et al., 2023; X. Zhao et al., 2023; Chen et al., 2024). Using VR technology, students can be transported to places and environments that they might not otherwise have access to, such as historical sites, foreign countries, or even outer space. For example, Google Expeditions is a VR platform that allows students to take virtual field trips to destinations around the world. Virtual reality technology is most commonly used in the biology learning domain. This is because biology needs a more complex visualization model so that students can see the learning concept more realistically and not just focus on books or material explanations by teachers.

*Safe Training Environment*

VR allows trainees to practice dangerous or high-risk scenarios in a safe environment, reducing the risk of injury and equipment damage (Stefan et al., 2024; Stefan et al., 2023). Provides a risk-free environment for trainees to practice handling potentially dangerous situations. They can make mistakes and learn from them without real-world consequences, ultimately increasing their confidence and competence in handling safety procedures. Virtual reality can also increase student engagement and motivation in the learning process. By providing an interactive and engaging experience, students tend to be more interested in the material being taught. VR can also provide a sense of adventure and excitement that can make learning more enjoyable.

*Repeatable Scenarios*

Trainees can repeat VR scenarios as often as needed to perfect skills and build muscle memory, ensuring consistent and comprehensive training results (Nowell et al., 2017).

*Customizable Simulations*

VR allows training scenarios to be tailored to specific learning goals and challenges, allowing for personalized and targeted skill development (Laine et al., 2024; AlGerafi et al., 2023).

### *Data Collection and Assessment*

VR systems can collect detailed performance data, allowing trainers to assess trainees' progress, identify strengths and weaknesses, and adjust training accordingly (Zechner et al., 2023; Muñoz et al., 2024; J. Zhao et al., 2024). Another advantage of virtual reality in education is its ability to provide personalized learning experiences. VR technology can be used to create customized learning environments that are tailored to each student's needs and learning style. For example, a language learning app called "HelloTalk VR" uses VR technology to provide an immersive language learning experience that is personalized to each student's learning level and pace.

### *Disadvantages of Virtual Reality in Science and Other Learning Interests*

#### *Motion Sickness*

Some users may experience motion sickness or discomfort due to sensory disconnection between virtual and physical movement, resulting in nausea and dizziness (Kourtesis et al., 2024; Zhang et al., 2024).

#### *Cost and Accessibility*

VR systems can be expensive to develop and maintain, making them less accessible to organizations with limited budgets (Pottle, 2019; Alam & Mohanty, 2023; Javaid et al., 2024). The requirement for high-quality hardware and software may also be a barrier to adoption.

#### *Ethical Concerns*

The immersive nature of VR may desensitize users to violence and blur the boundaries between reality and simulation, raising ethical concerns about its impact on perception and behavior (McIntosh, 2022).

#### *Learning Curve*

Some users may struggle with the learning curve associated with using VR equipment and navigating virtual environments, potentially impacting the effectiveness of training programs (Elhambakhsh et al., 2024; Grassini et al., 2020).

#### *Isolation and Social Disconnection*

Prolonged use of VR may lead to isolation from the real world and reduced face-to-face interaction, potentially impacting social skills and relationships (Kenyon et al., 2023; Finnegan & Campbell, 2023; Della Longa et al., 2022).

## **Conclusion**

Science education is directed at finding out and doing so that it can help students to gain a deeper

understanding of the natural environment. In education, VR offers great potential to create more engaging and effective learning experiences, especially in science learning. One of the main challenges in science learning is students' difficulty in visualizing abstract concepts, such as molecular structure, the solar system, or human anatomy. Virtual reality has advantages and disadvantages in science learning.

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### **Author Contributions**

Conceptualization, K.; methodology, I. P.; validation, A. W. P.; formal analysis, R. R. P. M. S.; investigation, R. A.; resources, K.; data curation, I. P.: writing – original draft preparation, A. W. P.; writing – review and editing, P. R. R. P. M. S.: visualization, R. A. All authors have read and agreed to the published version of the manuscript.

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### **Conflicts of Interest**

The authors declare no conflict of interest.

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