

IMPLEMENTING OF VIRTUAL REALITY TECHNOLOGY IN SCIENCE SUBJECTS AS EFFORT TO BUILD A MEANINGFUL LEARNING

PENERAPAN TEKNOLOGI VIRTUAL REALITY PADA MATA PELAJARAN SAINS SEBAGAI UPAYA MEMBANGUN PEMBELAJARAN YANG BERMAKNA

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ABSTRACT

The post-COVID-19 pandemic has resulted in learning loss in almost all subjects, including science learning. In addition, there is a decrease in motivation in capturing learning. In contrast, 21st-century education demands literacy skills accompanied by competencies and characters that lead to lifelong learning. Therefore, services in the form of technology that can improve students' skills and interests are needed, one of which is using virtual reality. This technology is believed to be a future asset that can help students construct their cognitive structures. Thus, this study aims to examine the use of virtual reality technology in improving meaningful learning in science learning at school. The method used in this study is a qualitative method with a descriptive approach through a literature review of Google Scholar and Scopus-indexed journals. The data that has been collected is analyzed by correlating the relationship between the use of virtual reality with meaningful learning in science subjects. After that, it ends by elaborating on the ideas in this article. Based on studies that have been conducted, it is found that virtual reality is a 3D technology that helps visualize science concepts that combine the real and virtual worlds (immersive) so that learning is more interactive. Despite its great potential, this technology should be used as a supporting tool, not a substitute for human interaction in learning. Virtual reality can also create meaningful learning by directly involving students in constructing their cognitive structures related to facts, concepts, procedures, and metacognition. In addition, this technology is also able to integrate science concepts that were previously fragmented to be integrated comprehensively through 3D virtual simulations. This will help create meaningful learning because students can understand science concepts comprehensively by connecting their experiences to real learning materials through immersive technology.

Keywords: Immerse Technology; Meaningful Learning; Science Subject; Virtual Reality



ABSTRAK

Pasca pandemi COVID-19 memberikan dampak learning loss hampir di seluruh mata pelajaran salah satunya pembelajaran sains. Ditambah lagi, terjadinya penurunan motivasi dalam menangkap pembelajaran. Padahal pendidikan abad ke-21 menuntut kecakapan literasi yang disertai dengan kompetensi dan karakter yang bermuara pada pembelajaran sepanjang hayat (lifelong learning). Oleh karena itu, dibutuhkan layanan berupa teknologi yang mampu meningkatkan keterampilan dan minat siswa salah satunya melalui penggunaan virtual reality. Teknologi ini diyakini sebagai aset masa depan yang mampu membantu siswa menkonstruksi struktur kognitifnya. Sehingga, studi ini bertujuan mengkaji penggunaan teknologi virtual reality dalam meningkatkan pembelajaran bermakna pada pembelajaran sains di sekolah. Metode yang digunakan pada studi ini adalah metode kualitatif dengan pendekatan deskriptif melalui kajian Pustaka jurnal terindeks google scholar dan scopus. Data yang telah terkumpul dilakukan analisis dengan mengkorelasikan keterkaitan pemanfaatan virtual reality dengan pembelajaran bermakna terhadap mata pelajaran sains. Setelah itu, diakhiri dengan menguraikannya menjadi gagasan dalam artikel ini. Berdasarkan studi yang telah dilakukan diperoleh bahwasanya virtual reality merupakan teknologi 3D yang membantu visualisasi konsep sains yang menggabungkan dunia nyata dan maya (imersif) sehingga pembelajaran lebih interaktif. Meskipun potensialnya besar, teknologi ini harus digunakan sebagai alat pendukung, bukan pengganti interaksi manusia dalam pembelajaran. Virtual reality juga dapat menciptakan pembelajaran yang bermakna (meaningful learning) dengan melibatkan langsung siswa untuk mengkonstruksi struktur kognitifnya sendiri terkait fakta, konsep, prosedur dan metakognitif. Selain itu, teknologi ini juga mampu mengintegrasikan konsep-konsep sains yang sebelumnya terfragmentasi menjadi terintegrasi secara komprehensi melalui simulasi virtual 3D. Hal ini akan membantu terciptanya pembelajaran bermakna karena siswa mampu memahami konsep sains secara komprehensif dengan menghubungkan pengalamannya ke dalam materi pembelajaran secara nyata melalui teknologi imersif.

Kata kunci: Teknologi Imersif; Pembelajaran Bermakna; Pelajaran Sains; Virtual Reality

INTRODUCTION

Over the last 10 years, learning processes in education have evolved to apply more interactive learning environments, especially in 21st century learning. The challenge of using digital technology has become a necessity to be implemented (Pringle et al., 2022). Plus, the recent Corona Virus Disease (COVID-19) condition has made a more drastic change in the learning process ((Prawira, Ayundari, & Kurnia, 2021). This is because the government has restricted the learning process in schools to the process of learning done at home with the term online learning. Even

Lennox, et al. (2021) that more than 90% of schools worldwide were closed during the COVID-19 pandemic. (Lennox et al., 2021).

This leads to learning loss in almost all countries, one of which is Indonesia. Jakubowski, et al. (2023) modeled the impact of school closures on student reading skills around the world using a linear regression model. The modeling results obtained show that the average score of student reading achievement decreased from 2016 to 2021 by 31% (Jakubowski et al., 2023). Even the World Bank Staff in 2020 also made predictions based on the

2018 Program for International Student Assessment (PISA) data which predicted an average decline of 11 points during the four-month school closure (Yarrow et al., 2020)

Therefore, it is necessary to provide educational services to students after the pandemic and improve students' ability to access and use these resources. In addition, it is necessary to emphasize the importance of developing tools to assess classroom practices and provide teachers with broader teaching insights so that students can accept the learning process. As a result, the learning process must emphasize the use of technology (Recch et al., 2023).

One of the current technologies that are in great demand by Generation Z students is virtual reality technology. This is based on study findings that show that because Generation Z was born and raised in a digital age with swift technical advancements, 62.9% of them are interested in technology and prefer it to traditional learning techniques (Gar Chi et al., 2021). Therefore, virtual reality technology has been developed in many academic circles that focus on education (Barry & Kanematsu, 2022).

Virtual reality (VR) technology is a technology that allows users to see and interact in a three-dimensional world. This technology includes visual and auditive experiences that produce an environment like the real world. VR can be used in education to create engaging and interactive learning experiences. The use of VR can increase student

understanding, knowledge, and engagement. This technology has great potential in transforming education and motivating students through active learning experiences (Barry et al., 2021).

In addition, science is practical learning and certainly benefits greatly from VR technology. This is because in science learning using VR allows students to gain practical experience and knowledge of the specified process without the risk of injury or danger that may occur in the real world. In VR, students can interact in a multiuser room in a three-dimensional and multidimensional virtual environment. VR also allows students to simulate repeatedly with different approaches, thus enabling learning that is personalized and tailored to individual learning paces. In addition, VR also allows students to visualize abstract and complex concepts in science, such as molecular structures or natural phenomena that are difficult to explain with words or static images. Thus, VR can help students understand science concepts better and strengthen cognitive skills especially in procedural knowledge (Laseinde & Dada, 2023).

Despite the great potential of VR and the high interest of Generation Z in the use of virtual reality, several studies discuss the effectiveness of the technology in enhancing cognitive activities in learning (Barry & Kanematsu, 2022; Chiquet et al., 2023; Ifanov et al., 2023; Suri et al., 2023). However, studies on the application of these technologies in creating meaningful learning have never been

reported. Therefore, further studies are needed regarding the potential of VR technology in creating meaningful learning that provides immersive, interactive, and practical experiences for students. Therefore, this study was conducted to examine the use of virtual reality technology in improving meaningful learning in science learning at all levels of educational institutions.

METHOD

This study is restricted to the scope of the application of immersive technology-virtual reality by reviewing the readiness, and challenges in the use of immersive technology in meaningful learning that will be implemented by educational units. In addition, the discussion in this material is also limited to the application of virtual reality in science learning, especially natural science.

This research uses a qualitative method with a descriptive approach by analyzing the problem and then elaborating it into ideas in this scientific work. In the data collection process, the preparation of this paper uses secondary data by reviewing relevant literature from scientific articles obtained from Google Scholar and Scopus-indexed journals. In addition, to reviewing the literature, data is also collected from media reviews obtained from the internet, print, and electronic media as input that supports ideas. After the data was collected, it was then analyzed using analytical techniques developed by Miles and Huberman (1996), namely data collection, reduction, presentation, and conclusion/verification. Meanwhile, in obtaining data validity, this study used

data source triangulation techniques. This technique is used to analyze the subject by cross-checking with other data (Miles, et al., 2014).

RESULTS AND DISCUSSION

Virtual Reality

Virtual reality (VR) refers to technology that creates a user's virtual immersion in a digital environment using computer-generated graphics that let them experience a three-dimensional world that combines their motor, sensory, and emotional senses. VR technology is now widely used in many different professions and sectors due to technological advancements. VR has been used in surgical education, language learning, sports training, tourism, and education, for instance (Villena-Taranilla et al., 2022a).

The main reasons virtual reality (VR) has become so popular in education are its innovative, interactive, and immersive characteristics, which combine the real and digital worlds. According to Blascovich et al. (2002), its application enables teachers to situate pupils in a real-world setting which is not possible with textbooks (Blascovich et al., 2002). Because of its application in education, students can immerse themselves in any setting at any time. According to Cuesta and Ma'nas (2016), this technology can be used to achieve experiential learning in educational settings by removing time and location constraints (Cuesta Cambra & Mañas Viniegra, 2016).

The Development of VR in the Education Field

Interest in educational research for the effective use of VR has increased significantly. Nevertheless, there are

currently few published studies assessing the potential of virtual reality (VR) technology for students in the classroom as well as instructional methodologies (Pellas, et al., 2021). Based on varying degrees of immersion, there are three types of virtual reality (VR) used in education: non-immersive, semi-immersive, and immersive (Villena-Taranilla et al., 2022b)

- a. Non-immersive VR is The most basic kind of VR, known as virtual reality, which displays the virtual world solely on a computer screen. More interactive and visual learning experiences, including simulations or visualizations of abstract ideas, can be offered using this kind of virtual reality. A 3D virtual world created and viewed only through the screen of an electronic device, typically a computer or laptop, is an example of how this technology is being applied. The keyboard and/or mouse are used by the user to interact with the virtual environment.
- b. Semi-immersive VR is a subset of VR in which the user experiences some degree of immersion in the virtual environment while maintaining a

sense of the physical world around them. Using projectors or flat displays to display virtual surroundings is one example of this kind of VR. With this kind of virtual reality, learning can take place in more realistic settings and involve interacting with virtual objects or models of environments.

- c. Immersive VR is the all-encompassing VR that is the most developed kind of VR and offers the most potent immersive experience. The user can interact with the virtual environment and feel completely immersed in it. Using a VR headset to see a three-dimensional virtual world and be able to move around in it is an example of this kind of VR. The most engaging and interactive learning experiences can be created with this kind of virtual reality (VR). These experiences can include virtual environment exploration or the simulation of abstract learning materials (like the material on molecules in chemistry classes and viruses in biology classes), allowing students to engage directly with virtual objects.

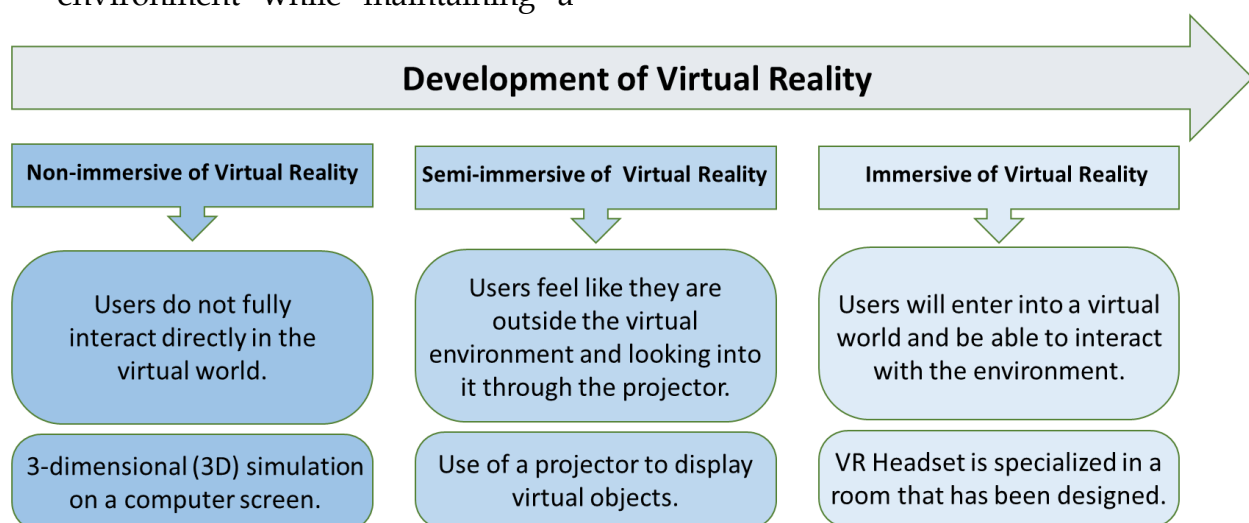


Figure 1. The Development of Virtual Reality Technology

Meaningful Learning

The knowledge structures of students are not necessarily well-structured; instead, they are made up of concepts from earlier experiences that are not consistently and methodically integrated (Steven, et al., 2013). Even while students may possess pertinent knowledge, fractured and disjointed frameworks may make it difficult for them to access and use them (Sirhan, 2007). Students may find it challenging to apply their information to novel situations and find solutions to challenges they have never encountered before if their knowledge structures are disjointed and unorganized. On the other hand, linkages and connections between concepts aid in the development of a clear integrated knowledge structure. Experts typically possess well-structured knowledge bases that make it simple for them to access and use concepts (Shin et al., 2003). The goal of instruction should be to help students acquire integrated knowledge so they can choose, relate, and apply concepts to new situations. A learning progression should outline the links and interconnections between concepts in addition to the information and abilities needed for more complex understanding to accomplish this educational aim (Stevens, et al., 2013). Implementing Meaningful Learning is crucial, for this reason.

Educational psychologist David Ausubel is credited with developing meaningful learning ideas. Ausubel (1968) is predicated on the receiving and discovering learning process, according to his observations. While students will act as subjects who will find the concepts they will learn on their own in

the finding-learning process, they will behave as objects in the receiving learning phase, where they will only learn from the teacher. Ausubel thus proposed a theory of meaningful learning as a process of connecting newly discovered knowledge to ideas that are already possessed by an individual's cognitive structure. Facts, ideas, and in-depth knowledge that an individual already possesses can all be included in the structure (Rahmah, 2013). According to Plotnick (1997), meaningful learning can also be seen in this way: as the integration of new ideas and propositions into preexisting cognitive structures, which results in the production of new cognitive structures (Plotnick, 1997).

In constructing new knowledge in the process of meaningful learning, Richard E. Mayer (2002) has identified five cognitive categories related to the transfer of knowledge to a new context, namely: understanding, applying, analyzing, evaluating, and creating. Each of these categories includes other cognitive processes. For example, the category of "understanding" includes processes such as interpreting, exemplifying, classifying, summarizing, concluding, comparing, and explaining, while the category of "creating" includes processes such as generating, planning, and producing (Mayer, 2002).

Challenges Associated with VR Education

It can be difficult to teach 21st-century skills in a classroom setting (Mcguire, 2018). This is justified by the fact that educational graduates need to be able to adapt to the demands of the modern workforce, which is always in need of

21st-century abilities like critical thinking, empathy, technical literacy, and inventiveness. However, these abilities are rather hard to teach and aren't given much attention in the classroom (Wrahatnolo & Munoto, 2018). This is just one of several elements at play, one of which is the necessity of technology to improve the quality of instruction. Every second, new technological advancements occur, making it very challenging for educators to stay up to date without acquiring the necessary technological abilities (Stošić, 2015). If instructors are not guided in the proper path, this gets tough. Therefore, additional training initiatives will eventually contribute to meeting the expanding demands (Lawrence, et al., 2019).

Teaching in a virtual environment has its own set of difficulties. Among them, educators lack proficiency in implementing classes using virtual technology (Monova-Zheleva, 2015), course development takes much longer than usually expected (Scott, 2015), for certain disciplines with extremely defined learning objectives, the time and effort necessary to construct virtual environments is not warranted. In fact, with these virtual technologies, students can become better prepared for a highly diverse and interconnected social world (Oke & Fernandes, 2020). However, a new challenge arises because virtual worlds require a strong internet connection and computing power. Students frequently cannot access this technology at home, and it is frequently absent from computer laboratories or classes that do not adhere to the minimal requirements for making the most use of virtual worlds (Christopoulos et al., 2018).

Virtual reality has the potential to be a very useful tool in education, particularly for scientific instruction. Utilizing this technology in the classroom can potentially have serious negative effects. In the traditional educational process, learning is predicated on interpersonal relationships and one-on-one human contact. VR, on the other hand, is highly distinct. VR creates a connection solely between the pupils and the program. The link between pupils and human communication will undoubtedly suffer as a result. So, the application of virtual needs to be emphasized that its use is only as a learning medium in assisting the learning process by introducing a material not replacing it (Gar Chi et al., 2021). Therefore, an educator must be able to understand the needs of learning materials that use virtual environments in learning activities so that the formation of a more developed student personality and the learning process can still maintain and improve human relations.

Reconstructing Science Teaching for Meaningful Learning

One of the main objectives of science teaching is to develop students' ability to explain real-world phenomena, make predictions, and solve problems using relevant ideas. This is so that students can become individuals who are skilled in problem-solving and have literacy in the context of science. It is sometimes required to combine concepts from several areas to describe a variety of phenomena. For instance, knowledge of matter's composition and characteristics, energy concepts, and conservation laws are necessary when examining chemical processes like

material transformation (National Research Council, 2012).

Unfortunately, science teaching and assessment often focus on providing information related to individual topics. For instance, descriptions of how solid melts typically concentrate on the structural variations between the solid and liquid stages, such as the arrangement of particles and their relative distances from one another. Nonetheless, a more thorough description of the energy transfer and transformation involved in the solid melting process, as well as how they relate to modifications in molecular motion and intermolecular interactions that regulate these structural alterations, would be necessary.

In this instance, guiding students to connect concepts related to matter's structure with a mechanical comprehension of matter's behavior and its sources might result in a deeper comprehension of the phenomena. This ought to facilitate students' application of information in novel contexts.

Energy, interactions, atomic and kinetic theories of matter, conservation, and equilibrium are concepts that are crucial for understanding most chemical processes as well as occurrences in several other scientific domains. These concepts provide a framework that helps students integrate knowledge from different disciplines into a coherent, science-based worldview. In this context, these concepts are often referred to as cross-disciplinary concepts in educational frameworks, or as unifying concepts in minimum competency standards (Renstrom, et al., 1990).

A lot of these ideas have connections and interactions with one another that

will allow for automated explanations of a wide range of events. Given that modern research is interdisciplinary, the capacity to form these sorts of linkages is becoming more and more crucial. Sadly, since they frequently have trouble making connections between these scientific ideas, students frequently perceive each experience as an independent, singular event. It takes clear instructional assistance, both within and between disciplines, to develop a thorough comprehension of these concepts and their applicability in many occurrences.

Therefore, reviewing learning practices that still seem fragmented into several concepts that are not integrated. Consequently, research published in 2013 by Stevens et al. created a set of lessons to describe how students learn about material transformations such as phase shifts, chemical reactions, dissolution, and diffusion. The paper clarifies, however, that many of the same ideas—particularly those about the composition, characteristics, and behavior of matter—are at play in all of these events. As a result, the study's primary goal was to create a more intricate learning program on the nature of matter. This learning sequence aims to provide students with an understanding of the connections between energy, conservation, interactions, rates of speed, and equilibrium as well as the structure of matter. This helps students recognize the similarities between these phenomena rather than viewing them separately. Rather than concentrating on a single area of knowledge, each level in the series addresses an integrated collection of concepts and abilities across many subjects. By doing this, it

produces a framework that enables pupils to make connections between concepts rather than merely memorize information. Additionally, it can highlight the fundamental concepts of conservation, matter's structure, and pertinent processes to clarify how matter transforms. This learning sequence will enable students to apply their knowledge in new situations better than an approach that only incorporates facts (Stevens et al., 2013).

The Potential of VR in Science Lessons as Meaningful Learning

VR provides an opportunity to increase student participation by combining several fragmented concepts into a unified whole through virtual visualization. It has been demonstrated that virtual reality may alter students' attitudes by raising self-efficacy and engagement levels. Students may learn in a new way through immersive, interactive, and hands-on encounters that offer compelling new experiences that they have never had before (Radianti et al., 2020). Even in scientific classes when the topic is abstract to the students (i.e., something they cannot macroscopically feel or see), the entertainment appeal and novelty of virtual reality may be utilized to divert and disengage pupils. Compared to conventional learning environments, VR increases student participation by providing powerful experiences in terms of immersion and presence. Consequently, enhancing the immersiveness of the learning environment through virtual reality stands to benefit greatly, as it may heighten students' sense of presence and invigorate the classroom (Huang et al., 2020).

Constructivist learning is another opportunity that VR offers. Constructivism is predicated on the idea that people may form their understandings of the ideas in their environment by experience and introspection. According to Hadjipanayi and Michael-Grigoriou (2020), students build their knowledge via significant encounters. This is because virtual reality (VR) may offer an immersive artificial environment where students can become learners who can develop skills through do-it-yourself learning techniques (Hadjipanayi & Michael-Grigoriou, 2020). Therefore, constructivist learning is best suited in a simulated environment. Virtual worlds and real-world learning opportunities facilitate inadvertent learning, as students discover and create knowledge not for their benefit but rather to accomplish a certain objective, leading to increased comprehension and knowledge (Sejzi & Aris, 2012). Today, much attention is paid to active learning that engages students to be active participants through feedback, discussions, and activities. Fransson, Holmberg, and Westelius claim that virtual reality (VR) has a huge potential to enhance the educational landscape by providing immersive learning environments that are actively engaged, customized, and self-sustaining for student accomplishment (Fransson et al., 2020).

VR also provides the potential for visualizing complex models, taking new perspectives, and creativity (Cook et al., 2019). To assist students in grasping difficult topics, virtual reality (VR) allows them to build anything they want as well as swiftly see and control items (Molina-Carmona, et al., 2018).

For instance, Michael Bodekaer Jensen and Mads Tvillinggaard Bonde created the virtual reality application Labster, which allows users to build science simulations in a three-dimensional environment.



Figure 2. Simulation of Atomic Structure Material Introduction Using Labster

Based on Figure 2, shows a simulation of the Labster platform. This platform was created to encourage educators to use it in the science learning process to make it easier for students to understand. Teachers can use Labster to teach science materials such as atomic recognition, molecular shapes, biochemistry, viruses, and more than 1000+ other simulations on the platform. Currently, the application has been used by more than 1,800 educational institutions with more than 900 thousand users. VR is excellent for producing material in addition to viewing it. Students will be able to use their imaginations and become more creative because of this. To reach students who require the most help, virtual reality (VR) can introduce significant new tactics and enhance the general learning environment.

CONCLUSIONS

Virtual Reality (VR) is an immersive technology that can be used as a medium in simulating science concepts in 3D visualization so that learning can be constructed more interactively and present a more in-depth experience. Although this technology is an asset for future education, the challenge of using this technology is the limitation of interaction between human relationships. Therefore, it is necessary to emphasize using VR as a medium that only supports the learning process rather than making it a substitute for learning process activities. In addition, VR is also believed to be a technology that supports the creation of meaningful learning by introducing science concepts. This is because VR technology supports the integration of several fragmented material concepts into a whole concept in virtual simulations (visualizing complex models) so that during the learning process students can reconstruct their cognitive structures.

Based on the limitations set in this paper, it is expected that further research will be able to describe the potential of VR in the context of other subjects. In addition, it is also expected that there is a study that describes the effectiveness of using virtual reality (VR), augmented reality (AR), and extended reality (ER) in the context of science learning to create meaningful learning.

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