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Augmented Reality (AR) and Virtual Reality (VR) Technology in Education: Media of Teaching and Learning: A Review

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Abstract - Augmented Reality (AR) and Virtual Reality (VR) are the latest technologies that provide a new color to the field of education. This study reviews the use of AR and VR in education, especially in the teaching and learning process. This study is library research. The analysis shows that AR and VR are the solutions for teachers and students as a medium in the teaching and learning process. AR embellishes existing reality with image elements, sound effects, or text. While, VR creates a new simulation environment that presents a specific topic to students in an engaging, interactive, and experiential way. Several subjects using AR technology in education are: 1) anatomy of living things in Biology, 2) atoms in Chemistry, 3) earth and space in Geography, 4) movie Screening in Film and Television, 5) Computer network topology in Informatics, 6) geometry in Mathematics, and 7) 3D Stories in History. Several subjects which use VR technology in education are: 1) digestive system in Biology, 2) geometry in Mathematics, 3) earth's surface in Geography, 4) artifacts and temples in History, 5) space in Astronomy, 6) surgical operation practicum in Medical, and 7) pilot training in Aviation education. However, AR and VR have benefits and limitations. There are several barriers to implementing AR and VR in educational institutions and some considerations in implementing AR and VR technology in educational institutions. It is hoped that AR and VR can be used as a breakthrough in education and a solution to improving the quality of education in the future.

Keywords: Augmented Reality (AR), education, Teaching and Learning

I. INTRODUCTION

Technological progress always brings big changes in every era. In the industrial era 4.0, more and more people from various backgrounds are applying technology (Asmiatun et al., 2020). With the change of times, the components that accompany it also evolve. Technology has an impact on nearly every aspect of education. The increasing technological advancements have afforded the area of education new possibilities (Tulgar, 2019). With all technology, we as teachers and students now have unlimited opportunities to take learning beyond the limited classroom and can now access the whole world, in just a few seconds with the right access and devices (T. N. Fitria et al., 2022).

Having access to this technology helps connect students to learning in a more authentic and meaningful way, especially with multiple possibilities for students to engage with content through the use of AR (Augmented Reality) and VR (Virtual Reality) tools. AR can be made for learning media that cannot be done directly, for example, by observing an object in three dimensions. Only by using a cell phone or laptop can we observe something without having to do it directly. Then for VR itself, students can do things that are prohibited during this pandemic. For example, learning sports that are not allowed but by using VR that connects all of our movement tools with a virtual we can see how our teacher practices movements virtually which we can then do as well and the teacher can assess our movements.

Virtual reality is a technology that can display objects as if they were in the real world (Ningsih & Firmansyah, 2020). Technological developments are so fast, now is not something surprising in this century. Various technological innovations for various fields have been carried out, both by individuals and corporations. Technology, which is now almost present in all aspects of human life, is indeed quite amazing and easy (Fitria et al., 2022). For example, technology in the field of communication makes it easier for humans to communicate and get data quickly, even today's technology makes it possible to accommodate large data sizes. Education is a field that cannot be separated from these technological developments.

Several current technological trends which are relevant to be developed for learning media include: First, Artificial Intelligence (AI). AI is a concept in technology that can imitate human intelligence and is expected to be able to imitate tasks that can be done by humans, such as deciding something, recognizing something, or recognizing a pattern or image (Fitria, 2021b). One of the uses of AI in this learning media can be used to identify students learning styles so that AI will decide what material students can choose and can determine what learning methods are suitable for them (Fitria, 2021a). The second is the Internet of Things (IoT). IoT is simply a technology concept that can connect all physical objects that exist in our daily lives to the internet network so that they can be accessed anytime and anywhere quickly and easily. One of the uses of IoT in learning is E-Learning which can be used as a virtual classroom and can even meet face-to-face with teachers/tutors virtually through devices connected to cameras. Another use of IoT in learning is the interaction between books and an application. The application can display the information contained in the book in a virtual form such as images, videos, or even 3D shapes. Third, Virtual Reality (VR) and Augmented Reality (AR). VR technology allows users to interact with an environment that is simulated by a computer system. VR brings users to be able to enter a state that is visualized as if it were real or happening in front of them. While AR is a technology that can combine two- or three-dimensional (virtual) objects into the real world. This AR technology allows users to project virtual objects as if they were real.

Those are 3 technologies that are currently trending and relevant to be applied to support student learning

facilitation. However, technological developments such as these three types of technology will directly impact all sectors of life, including education. The application of technology which is currently a trend in the world, we can now see that it has begun to be widely used for learning purposes. Such as the use of e-learning to support learning, which is one of the applications of Internet of Things (IoT) technology. In the future, there will be many technologies that can be involved in the learning process. If IoT-based technology has begun to be widely used in the world of education, in the future the use of AR and VR will increasingly emerge.

Based on the explanation above, the researcher is interested to know more about AR and VR including their use, benefits, and limitations. Therefore, the objective of this study is to review the use of Augmented Reality (AR) and Virtual Reality (VR) in education, especially in the teaching and learning process.

II. LITERATURE REVIEW

A. Augmented Reality (AR)

Augmented Reality (AR) is the realization of a virtual environment by adding virtual information to the physical real-world environment. AR adds virtual information not only to the real environment, but also to the streaming video and games, and provides a simpler appearance (Sutopo, 2022). Augmented Reality (AR) is a technology that augments the real physical world with computer-generated 3D virtual objects, allowing users to interact with them via their mobile devices' screens (Lee et al., 2017). Augmented reality is a way of viewing the real world (either in person or through a device such as a camera that creates real-world visuals) and "adding" to that visual world with computer-generated input (Zailani, 2022). While Ismayani (2020) adds that Augmented Reality is a technology that combines 2D or 3D computer-generated objects into the real environment around the user in real-time.

Augmented Reality (AR) is a type of technology that interactively combines real and virtual objects that will generate 3D objects to be displayed on the screen. Augmented reality is widely used in various fields, one of which is education. In the field of augmented reality, education is used as learning media to make it more interesting (Adami & Budihartanti, 2016). A learning media that utilizes AR requires a fairly good specification of a device or device in the form of a smartphone. The components of AR itself consist of animation/images in 3D and a camera that is integrated with the AR application. AR learning media also can visualize abstract concepts for understanding and structuring an object model enabling AR as a more effective medium following the objectives of the learning media (Mustaqim, 2016).

B. Virtual Reality (VR)

Virtual Reality (VR) is a human-computer concept that simulates the future world. Humans can explore the world virtually online. VR is an artificial application produced by various devices in real-life environments (Sutopo, 2022). According to Musril et al. (2020), virtual reality is a technology that can make the user enter the virtual world and interact in it because VR is a technology-based computer that combines special devices for input and output for users to interact directly immersive with the virtual environment as if they were in the real world. Computer assembly learning media based on VR can be utilized by students whenever and for fun so that students can learn without limitations in space and time.

Virtual reality can imitate or recreate the experience that is sensed sensorily by humans. Most virtual reality provides a virtual environment utilizing the sense of sight (Hasanudin, 2021). VR app helps users experience reality modified in different ways, by adapting the senses such as sight and hearing in addition. Virtual reality has features such as disconnecting experiences and interactions from the real world or combining them with the real world, thus making the real and virtual similar. Virtual reality is a simulated experience that offers a sensation similar to the real world. The standard VR systems typically use a VR headset or multi-projection environment to produce realistic visuals, audio, and other sensations that simulate the user's physical presence in a virtual environment. It means that the use of virtual reality devices will result in high immersion, which is an experience immersive experience that places the user in a virtual environment that surrounds the user so that the user feels that he/she is a part of it (Wibawanto, 2020).

III. METHOD

This research type is library research. The literary study technique consists of a sequence of tasks about the collection of library data, the reading and taking of notes, and the management of materials study. According to Zed (2004), in library research, the researcher encounters textual and qualitative information. The library's data is "ready for usage". This indicates that scholars are utilizing source materials that are already available in the library. General library data are secondary sources, therefore the researcher acquires secondary resources. In this section, the researcher outlines the theory, investigates the study through the literature produced on the subject, and synthesizes it to highlight critical concerns. On the Google Scholar website, the article search is conducted by entering the term "micro-learning." Articles from foreign and domestic journals pertinent to the issue under study were searched.

A qualitative study of the Miles and Huberman model was used for the data analysis, which included data reduction, data analysis, and a conclusion (Miles et al., 2018). In the reduction stage, the researcher simplifies (reduces) and discards unnecessary data in such a way that the data can produce information that is following the research. In the display stage, the researcher sings the data in the form of a table so that it is easy to understand.

Furthermore, the researcher describes the findings and then concludes with an answer to the existing problems.

Findings and Discussion

Findings

This study reviews the use of Augmented Reality (AR) and Virtual Reality (VR) in education, especially in the teaching and learning process including its benefits and limitations.

A. Benefits and Limitations of Augmented Reality (AR) and Virtual Reality (VR)

AR/VR makes learning more immersive and experiential. This leads to increased memory retention among students. It is very helpful for students with learning disabilities. AR and VR are expected to be one solution to overcome student boredom in learning (Sulistianingsih & Kustono, 2022). Both AR and VR analyze and simplify complex topics and concepts for better understanding. AR and VR also promote independent learning and independence among students. It is a great training tool and gives learners confidence. AR and VT make distance learning interesting and interesting. With its immersive nature, immersive technology can improve student learning experiences in a way that has never been done before, making the application of AR/VR technology in schools a worthy priority for educational institutions in Indonesia. For example, educators can package learning materials and experiences in the form of interactive multimedia or use augmented reality and virtual reality technology to increase interactivity (Kholifah et al., 2021). These two technologies, both AR and VR, support each other and enliven the development of the technology world. This can add to the experience in the world of education, create new experiences, and in the future will add intelligent technology support. AR and VR bring a new dimension to the interaction between digital devices and the real world. Media learning that uses this technology can easily improve student understanding because 3D objects, text, images, videos, and audio can be displayed to students in real (Fitria, 2022a).

Both AR and VR can increase curiosity & enthusiasm for learning. In absorbing information, students are not only fixated on visual books or other audio-visual materials, if there is an application of AR and VR in learning. Given that AR and VR produce a three-dimensional effect that visualizes real objects, this encourages students to better understand the lessons being taught and increases their curiosity to think critically. Through high curiosity, there is also a high enthusiasm for learning. Moreover, this AR and VR technology also allows more interaction than conventional learning. Both AR and VR encourage students to think creatively and critically. From a sense of increased enthusiasm for learning, boredom in the learning process can be overcome by the application of AR and VR technology in the classroom. This is because teaching and learning activities using AR and VR become more interesting and imaginative. Thus providing a new atmosphere in more modern teaching and learning activities.

AR and VR technology also encourages student engagement. They are free to interact with virtual objects. As a result, students can analyze, experiment, and gain experiences that enhance their learning. Both AR and VR make it easier for teachers in delivering material. The application of AR and VR in learning makes learning activities feel more fun. This is also useful for teachers as a medium for delivering material and facilitating the teaching and learning process. Teachers do not need to deliver too much material in lectures, because they have been assisted by this VR technology. The positive impact is that the application of VR in the delivery of material can increase the effectiveness and optimal learning outcomes of students. The long-term benefit is that the use of AR and VR in learning has the potential to improve the quality of education in the future. Considering the current generation Z is more interested in learning media that inserts technology in it, compared to conventional learning.

1. Benefits and Limitations of Augmented Reality (AR)

There are several previous research about the application of Augmented Reality (AR) in the teaching and learning process as follows:

Table 1. Previous Research about Augmented Reality (AR)

No	Research Article	Result of Study
1.	(Kysela & Štorková, 2015)	Augmented Reality (AR) can give the teaching of history a fresh and appealing appearance. **AR has considerable potential as a method for highlighting noteworthy aspects and bringing history to life through mobile device multimedia material.**
2.	(Saputro & Saputra, 2015)	Augmented Reality (AR) is a technology used to realize the virtual world into the real world in real-time. The human digestive system consists of the mouth, esophagus or esophagus, stomach, small intestine, and large intestine. **Using Augmented Reality which can realize the virtual world into the real world, it can turn these objects into 3D objects, so that the learning is not monotonous**

		and children are motivated to find out more, such as knowing the name of the organ and the description of each organ.
3.	(Kamelia, 2015)	**AR is a learning media to improve understanding of chemical concepts interactively** such as atomic structure and molecular shape in chemical bonds**. AR provides a more realistic interaction and is an advancement of a promising technology method that can motivate users to engage in more active learning systems.**
4.	(Sartika et al., 2016)	By applying Augmented Reality (AR) technology, **the delivery of learning information can be clarified because this application can combine the real world and the virtual world.** Not only displaying material, but the application can also display images of planets in 3D animated objects with audio.
5.	(Irfansyah, 2017)	The results of testing the Animal Recognition application using Android-based Augmented Reality (AR) can run on various Android mobile devices. Based on the results of the test data, it can be concluded that **this application based on AR can help increase students' interest and understanding in learning.**
6.	(Setyawan et al., 2019)	**The implementation of AR learning media shows very good results and is suitable for use as learning media, both in the classroom and independently** according to the results of the validation of learning design experts, media experts, and teacher validation as material experts. **Student responses to the use of this media in learning are very good. Students are enthusiastic about participating in learning and arouse student curiosity.**
7.	(Kusuma et al., 2019)	By using interactive media with Augmented Reality (AR) technology, **teachers can be helped in conveying Javanese script material, so that students are more interested in learning Javanese script.** Augmented Reality (AR) technology combines two-dimensional and or three-dimensional virtual objects into a real three-dimensional environment and then projects these virtual objects in a real environment.
8.	(Yapici & Karakoyun, 2021)	regarding Augmented Reality (AR) activities, biology teachers were overwhelmingly enthusiastic. **Some of the benefits of the AR activities were subject concretization, retention, excitement and entertainment, the opportunity to repeat, and multimedia support.** In addition to these advantages, some negatives were highlighted, including internet connection interruption, the need to maintain a stable phone, the passivation of students over time, the expense, and the unsuitability for all subjects.
9.	(Kurniawan & Kusuma, 2021)	The use of the **AR application for learning *Salat* or *Sholat* can increase students' interest in learning and the level of students' understanding** of the prayer material which is indicated by an increase in scores before and after using the application.
10.	(Restika et al., 2021)	**Augmented Reality can provide an in-depth experience and understanding more interactively and interestingly in learning the components of the Total Station tool.** This AR application only requires a Smartphone in its implementation so users can access it anywhere and anytime.
11.	(Ningrum et al., 2022)	**Augmented Reality (AR) integrated circulatory system electronic comic media can increase students' interest in learning**. AR can be used for the practice of learning the human circulatory system by utilizing augmented reality-integrated electronic comic media to increase the learning interest of fifth-grade elementary school students.
12.	(Wedyan et al., 2022)	**AR increases language skills and academic performance. Additionally, it decreases students' anxiety, boosts their creativity, and promotes teamwork and involvement.** In addition, the students had good sentiments concerning the use of AR for English language acquisition.
13.	(Shaumiwaty et al., 2022)	Teachers use Augmented Reality-based learning media in learning English well. **Using AR-based instructional media improves English subject-matter student learning results. Teachers and students feel that learning is more enjoyable in the learning process** based on the findings of the questionnaire used to acquire a score classified as excellent.

Based on the previous above, shows that more benefits than limitations to using Augmented Reality (AR) technology in the teaching and learning process. AR offers

significant potential as a way for bringing history to life through multimedia content on mobile devices by emphasizing notable features (Kysela & Štorková, 2015)**.** Using AR brings the virtual world into the actual world, these things are transformed into 3D objects so that learning is not repetitive and students are encouraged to study more (Saputro & Saputra, 2015)**.** AR is an interactive learning medium to enhance idea comprehension. AR delivers a more realistic interface and is a development of a promising technology that can encourage to participate in more active learning methods (Kamelia, 2015). AR may merge the actual and virtual worlds, and the transmission of educational content can be made more transparent. AR-based applications can boost students' interest and comprehension in studying (Irfansyah, 2017; Kurniawan & Kusuma, 2021; Kusuma et al., 2019). The deployment of AR learning media is ideal for classroom and individual usage as learning media. The students' responses to the usage of this medium for learning are quite positive. Students are eager to participate in learning, and their curiosity is piqued (Setyawan et al., 2019). The AR exercises provided subject concretization, retention, excitement and enjoyment, the option to repeat, and multimedia assistance (Yapici & Karakoyun, 2021). Augmented Reality can deliver a more immersive, interactive, and engaging learning experience. The integration of Augmented Reality (AR) and electronic comics into the circulatory system can boost students' enthusiasm for studying (Ningrum et al., 2022; Restika et al., 2021). AR improves both language skills and academic achievement. Additionally, AR reduces anxiety, enhances creativity, and fosters cooperation and engagement (Wedyan et al., 2022). Using instructional media based on augmented reality enhances English subject matter learning outcomes for students (Shaumiwaty et al., 2022). Besides, several drawbacks of AR include internet connection disruption, the necessity to keep a reliable phone, the passivity of students over time, the price, and the incompatibility with all topics/courses (Yapici & Karakoyun, 2021).

AR technology has several advantages so it becomes an alternative media in various sectors. These advantages are: 1) Expanding user perception. 2D and 3D objects in AR provide a wider picture to users. Not limited to the outside, the user will also see the ins and outs of the object deeper. This certainly creates a different perception to him of something he sees from various perspectives. 2) User experience. Not just seeing, the user also allows interaction in studying an object. The experience gained will feel closer and real. It's not just a theory that needs to be elaborated for so long without a clear implementation. 3) Flexible in various devices. The tools used by the user can be in the form of many options tailored to their needs. Starting from the most simple devices to those that are complex and require a high budget. From these advantages, it can be seen that the main purpose of using AR technology in education is to provide extra insight by explaining more interesting and in-depth topics. Currently, laboratory experiments using AR are rapidly developing. It is not uncommon for educational games to emerge that take advantage of their sophistication. Likewise with AR technology, which lacks tracking of the user's perspective, in which the application must know the user's location in advance.

2. Benefits and Limitations of Virtual Reality (VR) Technology

There are several previous research about the use of Virtual Reality (VR) in the teaching and learning process as follows:

Table 1. Previous Research about Virtual Reality (VR)

No	Research Article	Result of Study
1.	(Williams et al., 2018)	**Virtual reality (VR) provides a lot of educational potential for developing clinical skills without taking any risks. A VR simulation could teach emergency skills and highlight any obstacles** that need to be taken into account.
2.	(Taufiqurrohman & Sumbawati, 2020)	**Learning with the Project Based Learning learning model using virtual tour (Virtual Reality) learning media in the experimental class shows an average learning outcome value of 85.54. So virtual tour media is very suitable to be used in the simulation learning process of a Tour Guide.**
3.	(Pavlova et al., 2020)	Based on the material of Google Expeditions, StreetView, and Youtube 360, sample assignments for ecology students are designed. **Virtual reality technologies may be used to study specialized terminology for issues** of climate change, ecosystems, energy, forests, oceans, seas, and water. The authors believe that **"virtual immersion" in authentic surroundings will**

		enable students to master career-specific vocabulary when they are studying vocabulary.
4.	(Rachmatullah & Sukihananto, 2020)	**Virtual Reality has an influence and impact on students' ability to clinical simulations following the real environment in increasing knowledge and skills. Virtual Reality (VR) is a simulation learning media that can improve the knowledge and skills of nursing students.**
5.	(Bramantya, 2020)	Based on the average results obtained, it shows an **increase in results higher learning after using Virtual Reality media.** The existence of Virtual Reality-based learning media is expected to become a reference for the creation of more innovative learning media. **Virtual Reality-based learning media can serve as a model for the development of more innovative learning media.**
6.	(Purwati et al., 2020)	Virtual Reality application of Solar System Learning Media can facilitate the learning process related to the solar system. Users agree that the **Virtual Reality Application of Solar System Learning Media is effective in facilitating learning related to the solar system as evidenced by the results of the questionnaire** (60%) for the agreed value on the content aspect**. Users agree Virtual Reality Application Learning Media of Solar System efficiently facilitates learning linked to the solar system**, as indicated by a 60% agreement rate of the questionnaire.
7.	(Almira et al., 2021)	The test results of virtual reality-based learning media get an average percentage index of 86% and are in the "Very Good" category, so **Virtual Reality-based learning media is effective to replace written learning media that is of interest to students.** With the existence of virtual reality-based learning media, this media can be used by teaching lecturers and students in the teaching and learning process in the world of education, especially in basic photography subjects.
8.	(Arsadhana et al., 2022)	**The VR method is believed to be used as a future learning method because it penetrates the boundaries of space and time and can be used in all circles, including early childhood and students with special needs.** The disadvantages of VR are mainly in terms of health, expensive devices, and the limited internet network in Indonesia.
9.	(Ahmad et al., 2022)	**By utilizing Augmented Reality technology, the anatomical shape of the human body can be visualized** through three-dimensional (3D) virtual modeling using a smartphone. AR applications for cupping points on the anatomy of the human body can be operated on an android or smartphone has been built.
10.	(Darojat et al., 2022)	In learning Virtual Reality (VR) media is used as a complement to teaching materials for science subjects. **The results of product tests that have been applied to media experts, material experts, and students have received many positive responses, so it can be said that the virtual reality system of the solar system is suitable for use in learning.** This media makes it easy for students to analyze the arrangement of the solar system and provides an attraction for students so that an increased sense of learning arises. However, to use it, users must use a device that has a gyroscope capability.
11.	(Saepuloh & Salsabila, 2022)	After completing the teaching series, **the use of VR in learning English vocabulary at SD Negeri Cipanas 2 makes learning more interesting, effective, and fun. This can be seen from the enthusiasm and active participation of students when participating in learning.**
12.	(Fardani, 2020)	interest from users who tend to be very high in the use of Virtual Reality (VR) technology in learning. **The use of VR media has a significant impact on the level of pleasure and students' understanding of the material being taught. VR also makes learning more effective and efficient because will save time as well as costs.**
13.	(Ariatama et al., 2021)	**The use of VR encourages innovation in learning media that is different from before in increasing students' participation and critical thinking perspectives and bringing students closer to VR technology.** The characteristics of VR technology can be implemented in the teaching and learning process during a pandemic in attracting students' interest and feeling the atmosphere like in a classroom when offline learning takes place.

Based on the previous above, it shows more benefits than limitations of using Virtual Reality (VR) technology in the teaching and learning process. Virtual reality (VR) offers significant. A VR simulation might be used to educate emergency skills and identify potential difficulties (Williams et al., 2018). Learning with the Project-Based Learning model and virtual tour (Virtual Reality) learning media results in an average learning outcome Virtual tour media is ideally suited for usage in the Tour Guide simulation learning process (Taufiqurrohman & Sumbawati, 2020). A "virtual immersion" in authentic environments will allow students to grasp career-specific vocabulary when studying vocabulary (Pavlova et al., 2020). This is evident through the students' passion and active engagement in learning activities (Saepuloh & Salsabila, 2022). Virtual Reality influences students' capacity to replicate the real-world environment in clinical simulations, hence enhancing their knowledge and abilities (Rachmatullah & Sukihananto, 2020). The availability of Virtual Reality-based learning media will serve as a benchmark for the development of more creative learning media. Learning media based on virtual reality can serve as a model for the creation of more creative learning media (Bramantya, 2020). Virtual Reality-based learning media can effectively replace student-interesting textual learning media (Almira et al., 2021). Virtual reality is regarded to be a future learning technique since it transcends place and time and can be employed in all circles (Arsadhana et al., 2022). The anatomical contour of the human body may be viewed in three-dimensional (3D) virtual form using a smartphone and Augmented Reality technology (Ahmad et al., 2022). A virtual reality system of the solar system is ideal for educational usage. This medium makes it easier for students to study and attracts students so they develop a greater appreciation for learning (Darojat et al., 2022). The utilization of VR media has a substantial effect on students' enjoyment and comprehension of the content being taught. VR also makes learning more efficient and effective since it saves time and money (Fardani, 2020). The use of VR stimulates creativity in learning media that differs from the past by improving student engagement and views on critical thinking and bringing students closer to VR technology. In offline learning, VR technology may pique students' attention and simulate the classroom environment (Ariatama et al., 2021)**.** Virtual Reality provides a very realistic quality sensation for its use and can connect to certain other devices. The advantages of this technology are also very much like a realistic visual experience. It makes us able to interact with objects that exist when we use this technology which can usually be encountered while playing certain games.

Besides, VR technology also provides other advantages such as 1) Makes us able to see the beautiful scenery around the world both realistically and directly. This can be realized because VR technology carries a very realistic visual quality (T. N. Fitria, 2022b). So that the appearance of the environment presented by this technology almost resembles the original in 3D. 2) It makes us move a lot. If we usually play games using only our fingers, the data for playing games using this technology is different, because we will use many movements such as running, walking, or just moving our hands (T. N. Fitria, 2022c). In addition to having advantages, VR technology also has disadvantages, namely: 1) Manufacturing costs are more likely to be expensive. 2) Very limited to use and manufacture. 3) Can increase unemployment resulting in designing projects only taking a few people. Besides, the limitations of VR relate to health, pricey equipment (VR tools), and Indonesia's inadequate internet infrastructure (Arsadhana et al., 2022; Darojat et al., 2022).

B. Application of Augmented Reality (AR) in the Teaching and Learning Process

AR/VR can be implemented in various subjects such as 1) Science: Using the visual and sensory power of VR to teach students subjects such as human and animal anatomy, molecular biology, chemistry, and atomic physics. The training of astronauts and pilots makes extensive use of extended reality technology. 2) Literature: Virtual tours of historical buildings and archaeological sites in remote areas enrich the student experience of history, archeology, and political science. In addition, art students can experience firsthand the world's top museums and the works of art in them through VR. 3) Practical exercises: Using AR/VR to explain various business models and economic models to students in an easy-to-understand way. In business education, AR/VR allows you to visually understand and experience actual buying and selling, in-store experiences, production lines, supply chains, etc. This technology is very helpful for students in their work. 4) Architecture and engineering: The most popular use of AR/VR has been witnessed in the fields of architecture and engineering. Designers can use VR technology to better implement their vision by creating full-scale 3D models, as well as the limitations of physics and mechanics by creating the most imaginative and innovative designs. 5) Communication skills: Outside the discipline, VR technology is used by students to improve their

communication skills, especially their ability to speak in public. There is a VRe Learning (Virtual Speech Course) where students can choose the size of the crowd to speak to and practice their public speaking and presentation skills.

1. Application of Augmented Reality (AR)

Augmented Reality (AR) and Virtual Reality (VR) are one of the world's breakthroughs that can be adapted to various fields. Education (Supriyadi et al., 2022). The use of digital technology in the teaching and learning process has become commonplace. Today, the power of AR and VR is pushing education into the realm of experience. Students now have access to vast amounts of data and learning materials while teachers increasingly play a role as learning facilitators. Education is tailored to the needs of students. Teachers create online lessons to address specific learning gaps and increase understanding of specific topics that require deeper learning interventions. Besides, AR and VR technologies have been introduced to optimize learning outcomes using simulations, 3D images, and advanced audiovisual effects.

Several subjects using Augmented Reality (AR) technology in the teaching and learning process are as follows:

a. Anatomy of Living Things in Biology

In biology subjects, AR-based media will be very helpful for teachers and students. Especially in studying the anatomy of various creatures. Looking at just one cell will provide a very different experience if only viewed using a microscope. 3-dimensional visualization in AR displays the shape of cells from various sides. Students can study every inch of the cell side they see. If using a microscope, students can only pay attention to its shape. However, when AR-based teaching media is used, everything he sees is equipped with theory and there is a lot of additional information that does not exist in other teaching media.

b. Atoms in Chemistry

Similar to knowing the anatomy of living things, exploring the atomic world will be more interesting with AR media. The process of how the atom was formed until its journey merges with other atoms can be enjoyed by students. Students can freely explore more knowledge in it. The possibility is to interact with objects is the main attraction. The absorption of material will be easier by involving students' emotions.

c. Earth and Space in Geography

Materials about earth and space need this technology. Many educational institutions have implemented it to support geography subjects, whose terms are often difficult to understand. Teachers are also motivated to accompany their students in exploring the sides of the earth and outer space. Teaching media is no longer just fixated on atlases and globes. These props are less relevant in this day and age because they are rigid and tend to be boring. The presence of AR has indeed become a new hope in the world of education to continue to develop quickly and efficiently.

d. Movie Screening in Education

Teachers can also show the sophistication of AR by presenting this technology-based educational film or video. The video that is watched must of course be related to the subject matter to be discussed. Usually, videos or films that use Augmented Reality provide more evocative visuals. The image quality and the atmosphere built into it make the audience feel more real. You can also start this way in class. Provide a memorable learning experience to our students.

e. Computer Network Topology in Informatics

For those of you who teach in the Computer Network department, as much as possible try to start applying AR in learning. The reason is, there are enough vocational schools that use it to explain to students about computer network topology. Several applications have also been launched to support the learning process in this field. Details of the computer network topology that is fairly complex can be parsed and studied independently. During the learning process, students will increase their achievement in understanding the material without having to repeat it many times.

f. Geometry in Mathematics

Who would have thought that learning to build space could also be more fun? Yes, thanks to the presence of AR-based technology, problems in geometry can be solved simply. If the school where we teach has not implemented it, then immediately apply it to increase the quality of teaching and learning. Students who are afraid of math no longer have a reason not to study. This media is an alternative that helps students understand without having to force them.

g. 3D Stories with History

Introducing history to students also requires innovation. Currently, AR technology is not only focused on developing exact category education. The

social sector also needs a sophisticated role to attract students' interest in learning. Especially if there are media who use 3D glasses when showing historical stories. They will take it seriously because they are involved in it. Based on the research mentioned above, the role of Augmented Reality technology is very influential in the learning process. Motivation and willingness to learn more deeply is a tremendous effect on students. If we haven't used this method at all, don't hesitate because it has a very positive effect. Not only for our students but also for ourselves. The examples of the application of AR in learning that have been described above are just a few of the many samples. The rest, many other subjects also use it continuously.

2. Application of Virtual Reality (VR) in the Teaching and Learning Process

In the world of education, Virtual Reality (VR) has begun to be applied. Through the concept of multimedia and its three dimensions, it can be used to support education and increase the effectiveness of student learning. The following is an example of subjects in the implementation of Virtual Reality (VR) in the learning process.

a. The digestive system in Biology

Material about the human digestive system is difficult to see directly because most of it is in the body. Using visual aids is still considered conventional because they cannot display blood flow, heart rate, or other organs while working in the body. Therefore, the application of VR in Biology can be a solution to these obstacles. VR as an alternative learning media to introduce the digestive system to humans can make students interested in learning it.

b. Geometry in Mathematics

Math subjects can also be done with VR. One of them is Geometry which discusses the shape, size, relative position of images, and the nature of space. For example, in geometry, students can learn about cones, spheres, cylinders, and polyhedra curves in three-dimensional space.

c. Earth's surface in Geography

VR in Geography can also be applied. For example, on material about the Earth's surface. Usually, students only see through pictures in books or videos. With technology for education such as VR, students can see clearly in a form like in the real world. Moreover, one of the advantages of VR in learning Geography is its ability to present nature in a wide field.

d. Artifacts and temples in History

Studying the past can also use this technology. Artifacts or temples in the past can only be seen from pictures or videos that tend to be boring. The application of VR in history learning allows students to see past environmental and social conditions, including historical heritage objects. This encourages students to interact and think critically about past lives.

e. Space in Astronomy

Studying the universe directly usually schools visit the Planetarium and Observatory building. There, there are props of planets and celestial bodies, as well as a simulation of the night sky. However, it is less efficient, especially during a pandemic. The application of VR technology allows students to study the universe in class and even at home. With 3D concepts displayed, getting to know planets and other space objects is clearer than visuals in books or videos.

f. Surgical operation practicum in Medical Education

This technology also benefits schools of prospective doctors who are learning to perform surgical operations. Compared to having to use a doll or a human body, the use of VR in doctor training is more efficient, because it can minimize costs and the results of the exercise can be analyzed in depth.

g. Pilot training in Aviation Education

Prospective pilots or pilots can even practice flying a plane without flying a real plane. It is also effective and reduces the risk of accidents. Especially if doing fighter pilot training, students can practice shooting without having to waste real bullets, because VR simulates situations in a virtual environment exactly like the real environment.

C. Barriers to the Application of AR and VR Educational Media in Educational Institutions

Augmented Reality (AR) and Virtual Reality (VR) technologies are now increasingly popular and widely applied in education because of their undeniable benefits. With the implementation of educational media through AR and VR devices, students' interest and level of understanding of learning materials increased rapidly. Through the media of Mixed Reality (MR) glasses, there is no need to be complicated and elaborate in explaining the subject matter. It has the potential to redesign and revolutionize the way we teach and learn. However, until now AR and VR education still have obstacles

that become challenges in their implementation, here are 5 obstacles as follows:

1. **Problems with the Availability of Funds**

   A major obstacle to the public education system is a lack of funds. Investing hundreds of millions of rupiahs in new technology equipment in education, plus setting up the necessary safeguards and training costs, makes this a pretty big obstacle. But judging from the benefits that can improve the quality of education, it means that there will also be an increase in the quality of human beings in this country. Moreover, if the government also supports and participates in realizing the application of this educational technology, of course, the investment is very feasible.

2. **Lack of Investment**

   Production of a product in large quantities can lower the market price for that product, making it more affordable, including AR and VR products for this educational technology. But to produce in large quantities requires a large amount of investment as well. The investment to produce this educational technology is still low. The role of the government is urgently needed to solve this problem because it returns to the previous point that the impact of the implementation of this educational technology is an increase in human quality, and the impact will be felt by the increasing development of the country in a positive direction.

3. **Quality Content**

   Content is important because it is something that users of this AR and VR educational technology will consume. What's a technology without useful content for its users? In this case, to encourage schools or other educational institutions to buy this educational technology, of course, they need a reason why they should buy it, and one of the main drivers is content that is useful, quality, and can improve the quality of education with teaching materials that are easier to absorb. by students, and make it easier for teachers to deliver subject matter.

4. **Distribution and Launch**

   Distribution is directly related to investment. When there's no widespread distribution, it's hard to raise funds to create "interactive stuff," as in the case of Chromebooks for reference. Chromebooks have a great price point and have managed to expand their market to schools. But it happens at different rates in different places. AR and VR will likely go down a similar path with Chromebooks.

5. **Transitional Technology**

   As with any new technology change, there will be a transition period to getting comfortable with new formats and platforms. This can be an obstacle when teachers cannot follow the transition period. Technology in the classroom that is immersive and interactive is very interesting to apply. Rather than passively reading about the experiences of others, students should actively build their projects such as executing, repeating, and learning. The obstacles above will be a challenge for developers to immediately find a solution, this is because AR and VR itself have enormous potential if they can be developed and applied in the learning process for children.

D. Considerations for Implementing AR/VR Technology in Schools

With its immersive nature, immersive technology can improve student learning experiences in a way that has never been done before, making the application of AR/VR technology in schools a worthy priority for educational institutions in Indonesia. In addition to transforming classroom learning from conventional to modern and interactive, VR technology also allows students to go on virtual museum tours, conduct field trips, experiment in virtual laboratories, and participate in activities that would not be possible in the real world. All of this can be done from inside the classroom without leaving the room, making it the perfect technology as a solution for learning outside the classroom during the COVID-19 pandemic and making distance learning practices more effective.

Unfortunately, Augmented Reality (AR) and Virtual Reality (VR) technologies have not yet become mainstream in Indonesian schools, which makes it difficult to incorporate them into the curriculum. Of course, it will not be easy to implement in real terms in Indonesia, but it is also not impossible to do. The following are some things that educational institutions in Indonesia must pay attention to so that the application of AR/VR technology in schools/institutions becomes easier and more effective, as follow:

1. **Quality Standard Evaluation**

   AR and VR are relatively new tools in the learning space, it can be difficult to judge and sort through quality content. Teachers/lecturers must ensure that the content is still following the existing educational curriculum in each region. Ideally, when planning virtual content to be implemented in the classroom, there should be a variety of topics, so that students experience new things, deepen their knowledge, and broaden their horizons. It is even more effective if there are different types of learning content, such as animations, videos, and interactive games to expand the imagination of the learner and avoid predictability. To take the advantage of AR and VR, students' senses must be stimulated, so that

they are fully engaged and immersed in the lesson through both auditory and visual components. Both students and teachers can use this technology to replay, pause and skip content, so they can learn and teach at their own pace and have complete control over content delivery.

2. Going Beyond Traditional Education

When preparing for the integration of AR/VR technology in schools, it is important not only to stick to traditional subjects but also to use technology to lead students into new learning areas. Educators can play an important role in facilitating learning and using technology to achieve these goals, which is why using technology in new ways should be at the forefront of our minds when integrating something new like AR/VR into the learning experience. By placing students in different situations that are physically impossible in the classroom, they will be able to experience sensations they would normally never feel.

3. Using Teacher Training

VR and AR technologies offer completely new learning experiences for students, but they can also enhance the skills of educators. A study published in Educational Science notes that teachers must continue to practice to keep pace with the development of AR/VR technology. This will ultimately enhance their skills as educators rather than replace them. It's also worth noting that because VR and AR can simulate real-life classroom settings, teachers can use them to test course materials they want to apply in class, allowing them to practice and improve their classroom management skills during the process. While it is not yet mainstream, VR/AR will soon change the classroom and the way different subjects are taught. Teachers and students will no doubt benefit from this technological evolution. VR and AR are technologies that can revolutionize education.

In my opinion, this breakthrough can be called "AR and VR drive student understanding". This breakthrough can be done by raising several tens of thousands of VR cameras that are given to schools in the archipelago. With this innovation, it is hoped that it can encourage the insight of students who are now far behind due to the pandemic. Activities that cannot run can be carried out again through AR and VR such as research, experiments, to sports activities. As a young generation, we can also create more learning media with AR, for example, cards that can be scanned with mobile phones which then appear with the AR scanner application. Or we can also make special books that can be scanned too so that students who don't like reading books can easily understand learning through this method. Especially if the student has a visual way of learning, of course, this will further support his understanding.

IV. CONCLUSION

Today's increasingly sophisticated technology does not need to be doubted. Augmented Reality (AR) and Virtual Reality (VR) are examples of technology that present a new experience for their users in the education field. However, both of these technologies have benefits and limitations. It is important to distinguish between Augmented Reality (AR) and Virtual Reality (VR) to better understand their impact on education. Augmented Reality (AR) embellishes existing reality with image elements, sound effects, or text. Virtual Reality (VR), on the other hand, creates a new simulation environment that presents a specific topic to students in an engaging, interactive, and experiential way. This technology is one of the solutions for teachers and students as a learning medium. Several subjects using Augmented Reality (AR) technology in the teaching and learning process are: 1) anatomy of living things in Biology, 2) atoms in Chemistry, 3) earth and space in Geography, 4) movie Screening in Film and Television, 5) Computer network topology in Informatics, 6) geometry in Mathematics, and 7) 3D Stories in History. Several subjects which use Virtual Reality (VR) technology in the teaching and learning process are: 1) digestive system in Biology, 2) geometry in Mathematics, 3) earth's surface in Geography, 4) artifacts and temples in History, 5) space in Astronomy, 6) surgical operation practicum in Medical education, and 7) pilot training in Aviation education. This research has not been tested on research subjects due to obstacles in the field and become suggestions for further research.

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