ANALYSIS OF THE USE OF *AUGMENTED REALITY* IN FLAT SURFACE BUILDING MATERIALS

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Abstract

One of the technologies that has been widely used is Augmented Reality (AR). In this study, the author discusses an Augmented Reality application related to the world of education. One of the roles of AR in the world of education is in the process of increasing interest in learning. The nature of AR is to help users more easily recognize an object or thing in 3D form, but there are still many ordinary people who do not know the limitations of its use. To support this, an Augmented Reality application is needed that can provide support for the appropriate research process. The AR research process uses a blackbox table that includes button checking, camera distance, and angle. The author designed an Augmented Reality application using the waterfall method. The research was conducted by finding the minimum camera range distance, minimum camera range angle, and minimum light on the marker on three Android devices to determine the optimal alternative.

Keywords: Augmented Reality, Mathematics, 3D form

INTRODUCTION

In today's modern era, technological developments are inevitable. These technological developments have entered all areas of life, including education. At the educational stage, children tend to be attracted to learning media that contains interesting and easy-to-use 3-dimensional (3D) objects. Meanwhile, current learning methods still mostly use images and text in the form of books and other teaching aids. *Augmented Reality,* or AR for short, is a technology that combines virtual objects with real objects. According to Ronald Azuma in 1997, *Augmented Reality* is a variation of *Virtual Reality*. *Virtual Reality* technology completely immerses users in a synthetic environment. When users are immersed in this environment, they cannot see the real world. *Augmented Reality* allows users to interact with the system in *real time*. *Augmented Reality* is a concept that combines *Virtual Reality* with *World Reality*. Thus, 2-dimensional (2D) or 3-dimensional (3D) *virtual* objects appear to be real and blend with the real world.

Science and Technology (IPTEK) plays a very important role in all fields. For example, in the social field, the health field, the economic field, and especially in the field of education. Technological developments from year to year have become more sophisticated because they are based on innovative and creative human thinking (al, 2019.) . The development of IPTEK in the field of education itself, such as the use of technology in learning media, aims to facilitate teaching and learning activities

between teachers and students. Similarly, according to (Khairunnisa and Aziz, 2021) , the use of technology in learning is to spontaneously connect the activities carried out during learning with technology-based media. However, in reality, teachers still use learning media in the form of textbooks or student worksheets (LKPD), because these media are considered the easiest to make and use (Meilindawati et al.) . In fact, when viewed from their development, textbooks or LKPD have shortcomings because they are considered unable to provide what teachers or students need. Difficulties in reading and understanding the content presented in textbooks are considered one of the reasons students become bored during lessons (Bagus et al.) . Therefore, learning media that can help students understand the content and visualize mathematical shapes is needed.

According to *, smartphones* are a technology that continues to develop rapidly to this day. People from all walks of life are sure to have at least one *smartphone*. Therefore, it is certain that students also have *smartphones*, whether it is one *smartphone* or even more than *one*. The more students who own and use *smartphones*, the greater the opportunity to utilize technology in education. One technology that can support mathematics learning using *smartphones* is *Augmented Reality* Technology. The advantages of using AR-based learning media are that it helps teachers deliver material, saves time, and creates an interactive and enjoyable learning atmosphere (Saputra et al.) .

Augmented Reality has characteristics as an interactive learning medium that is visible and directly perceived by students (Nurhaliza et al., 2022). The emergence of AR virtual objects can help users (students) interact directly with the objects being studied. This AR technology can also be easily accessed via *smartphones*. Another characteristic of AR is that it serves as a bridge between the virtual and real worlds, with significant interaction between the two, and the ability to display 3D objects (Kartini, et al., 2020). According to Afifi et al. (2021), the use of appropriate learning media is expected to reduce the level of abstraction of material content, attract students' interest in learning, and improve student learning outcomes.

Education in the 21st century should utilize technology in learning, such as learning that utilizes technological assistance such as AR technology systems. Based on this description, this study aims to conduct a review of *Augmented Reality* in mathematics learning. A similar study by Meilindawati et al. (2023) is related to the Application of *Augmented Reality* (AR) Learning Media in Mathematics Learning. However, the discussion only covers its implementation in mathematics learning. Based on previous research ( ), this study aims to describe the material, learning model, objectives, and types of research most frequently used by other researchers on the topic of AR use in mathematics learning.

RESEARCH METHOD

The researcher realizes that there is a lack of journals discussing *Augmented Reality* technology that can be implemented in the field of education in Indonesia,

especially in mathematics, so this study aims to explain what and how AR technology is used, as well as its impact on increasing student motivation. This research method uses a qualitative approach and applies a literature study research method, commonly known as *library research*. According to Mestika Zed (2014), literature study research has a main characteristic, namely that researchers deal directly with available sources, in this case journals. The analysis technique used in this study is *content* analysis. In answering the questions in the introduction, data is needed, and then content analysis is performed on the data to answer and describe it.

RESULTS AND DISCUSSION

1. Augmented Reality (AR)

Augmented Reality (AR) can be considered as a series of connections between the real environment and the virtual environment. AR is a type of "*mixed reality* (MR)" in which a digital object or object in a virtual environment is inserted into the real environment, unlike *Augmented Virtuality*, where objects or content in the real environment are transformed into a virtual environment.

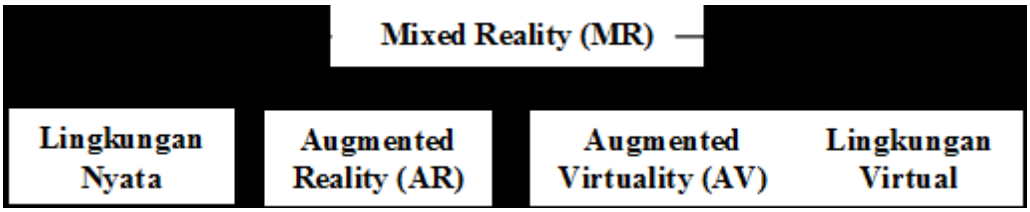

Figure 1. Real environment – virtual environment sequence. (Source: *Bower et al. 2014. Augmented Reality in education - cases, places, and potentials*)

Thomas P. Caudell in 1990 in *"The Term 'Augmented Reality'"* introduced the concept of AR for the first time. There are three characteristics that describe that the technology applies the AR concept (Balandin et al., 2010), namely:

a) It can combine the real environment with the virtual environment
b) It can display or provide information interactively and in real time, or as if the virtual object actually exists
c) It can display virtual objects in three dimensions

Then, Azuma (1997) stated that there are several requirements that are the main characteristics of a device that can be said to be an AR system, namely:

a) There is a camera that can record video to capture images directly
b) It has a powerful processor to combine virtual objects with the real environment or display 3D objects in real time
c) A display that allows users to interact with both virtual and real objects

From the above explanation, it can be concluded that *Augmented Reality* (AR) is a technology that combines real and virtual objects simultaneously in the same space and interacts in *real time* or as if the virtual objects were real (Bower

et al., 2014). Combining the real world with the virtual world has a contextual impact that is both memorable and meaningful. AR allows users to see the real world or real objects virtually. Virtual objects that can be incorporated into AR systems include text, images, 3D models, videos, sounds, and animations. Interestingly, these virtual objects will be considered to exist or coexist in the real world environment.

2. Augmented Reality (AR) technology systems in improving student motivation and the quality of learning

Several studies show that AR technology can help students develop their skills and knowledge in a more effective way (Estapa & Nadolny, 2015), which is also in line with the goals of SDG 04. The use of AR technology is one of the efforts to improve the quality of the learning environment. AR can increase student motivation and interest, as well as produce a more effective and deeper understanding of the learning process (Wu et al., 2013; Estapa & Nadolny, 2015). Therefore, the implementation of AR in mathematics learning has the potential to improve mathematical activities, both technically and conceptually, accompanied by an increase in student motivation.

The rapid advances in technology and the features provided by gadgets and AR software programs have led to increased accessibility to education. The mixed system possessed by AR technology can also be referred to as an *interactive print* system (Estapa & Nadolny, 2015). Currently, this system can be used by adding a marker such as a QR code, which becomes an important part of the interactive print system that functions as a link between the user and the AR content contained therein. Over time, the features provided by gadgets have also evolved, so that the system can not only activate AR content using QR *codes*, but it can also recognize the overall layout and design of a page to detect and identify which documents use AR technology features, as shown in Figure 2. For example, a cube image is added to a page in a book, and then students can point the camera on their gadget at that page, and the AR content will immediately appear on their gadget screen. A B

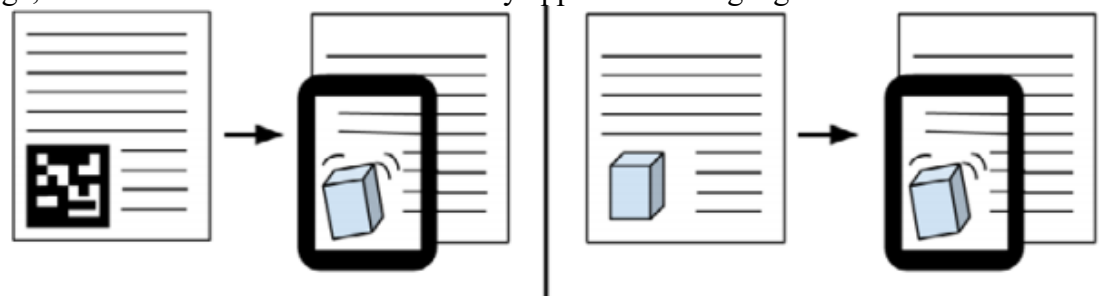

Figure 2. A) AR using QR Codes, B) AR using images. (Source: *Estapa & Nadolny. 2015. The Effect of an Augmented Reality Enhanced Mathematics Lesson on Student Achievement and Motivation*)

Bower et al. (2014) state that there is some literature showing that AR technology systems can support and enhance several types of approaches in

learning (Johnson et al., 2010; Shelton, 2002). Learning approaches that can be supported by AR technology systems include:

a) *Constructivist learning*, using AR technology, where AR can encourage students to be more involved in the learning process. In addition, students can also explore and make connections between basic knowledge or knowledge they already have (Kerawalla, Luckin, Seljeflot, & Woolard, 2006).
b) *Situated learning*, contextual learning allows learners to feel that learning fosters educational experiences in the real world and brings the real world environment into the classroom (Chen & Tsai, 2012; Dede, 2009; Dunleavy et al., 2009; Rasimah et al., 2011).
c) *Games-based learning*, AR systems can be used to facilitate an engaging game-based learning process by creating a digital narrative, placing learners in a role, and developing contextually relevant information. AR systems can transform real environments into virtual environments, where the games played can produce skills in applying knowledge to real environments in a simpler and easier way (Brom, Sisler, & Slavik, 2020).
d) *Enquiry-based learning*, AR systems provide virtual models that are displayed in real environments and are easy to manipulate. AR also supports investigation by presenting relevant and contextual information on the topic being discussed (Johnson et al., 2010).

From the above explanation, we can see that AR technology systems can be used and utilized as a learning medium, especially in mathematics learning. This is also in line with the goals to be achieved in the era of industry 4.0, namely digitization in the educational environment. Several researchers have also conducted studies and proven that AR can increase students' motivation, interest, and learning outcomes.

3. The impact of using Augmented Reality (AR) technology

As in the research conducted by Yu-ching Chen (2019), the article states that technology is developing rapidly in line with the changing times, one of which is AR technology, which provides an attractive visual experience for students. AR also has the potential to stimulate the learning environment in increasing motivation and the learning process and reducing the anxiety felt by students due to mathematics. Motivation is an important factor in the learning process (Chatzisarantis et al., 2015; Chen, 2019). Students with high motivation will be more involved in learning activities, which leads to a better learning process (Wu & Tai, 2016; Chen, 2019). Lack of interest and motivation in mathematics learning may stem from previous learning failures, which cause increased anxiety in mathematics learning and low self-confidence (Ramirez et al., 2018; Chen, 2019). Using Keller's ARCS (*Attention*, *Relevance*, *Confidence*, and *Satisfaction*-) model can improve the quality of learning designs integrated with technology, such as the use of AR technology. The model has four factors, namely:

a) *Attention*: with appropriate design, learning materials or media can attract students' attention and encourage them to explore and understand a lesson more deeply (Keller & Suzuki, 2004; Chen, 2019).
b) *Relevance*: Learners will be more motivated if the content or material is relevant to their goals, needs, and experiences (Keller & Suzuki, 2004; Chen, 2019).
c) *Confidence*: The more successful a learning experience is, the more motivated learners will be to improve their performance in the learning process (Keller, 2008; Chen, 2019).
d) *Satisfaction*: Learners will be more motivated when they feel that their learning experience is successful and satisfying (Rodgers & Withrow-Thorton, 2005; Chen, 2019).

The learning environment using AR technology and integrating Keller's ARCS model with efforts to help learners, especially those with high anxiety towards mathematics, aims to increase motivation and achievement in mathematics learning and reduce their learning anxiety levels. This study found that students who used Mobile AR (MAR) had higher motivation, better performance, and lower anxiety compared to those who did not use MAR. Students who used MAR considered the system useful, enjoyable, and easy to use. The visual appeal and experience provided by MAR features, which are not usually available in mathematics classrooms, helped those with high anxiety levels to encourage their learning experience (Chen, 2019).

These results are also supported by research conducted by Anna Estapa and Larysan Nadolny. In this study, several indicators were used, such as: 1) *Achievement test*, showing that the scores produced in the experimental group (using AR) and the control group both increased in the post-test compared to the scores produced in the pre-test. 2) *Motivation survey*, the group that used AR as a learning medium agreed that the learning was more interesting and could increase their curiosity about the learning they were doing. 3) *Open-ended question*, one of the comments from students regarding the learning process using AR said that they were very happy to be able to interact with mathematics through technology. Furthermore, the results of research conducted by Evi Syahida, Suprakarti, and Aris Hadiyan produced an Android-based learning medium on coordinate systems that is capable of presenting coordinate system material in 3D using AR technology, not only in 2D text and images . The research also stated that learning media with AR technology is valid, indicating that the media is suitable for use and can be continued in large-scale trials. Small-scale trials showed an average media score of 79.6%, while large-scale trials showed an average media score of 81.2%, an increase from the small-scale trials (Syahida et al., 2020).

CONCLUSION

Based on the problems outlined above, it can be concluded that *Augmented Reality* (AR) is a technology that combines real and virtual objects simultaneously in the same space and interacts in *real time* or as if the virtual objects were real. The implementation of AR in mathematics learning has the potential to improve mathematical activities, both technically and conceptually, accompanied by an increase in student motivation. Bower et al. (2014) stated that there is some literature showing that AR technology systems can support and improve several types of approaches in learning (Johnson et al., 2010; Shelton, 2002). Learning approaches that can be supported by AR technology systems include *Constructivist learning, Situated learning, Games-based learning,* and *Enquiry-based learning*. Furthermore, research conducted by Yu-Ching Chen (2019), Anna Estapa and Larysan Nadolny (2015), and Evi Syahida, et al. (2020) found that *Augmented Reality* technology systems have the potential to increase interest, motivation, and results in a learning process, especially in mathematics learning.

REFERENCES

Al Ikhsan, Indrawan, et al. "Augmented Reality-Based Learning Media: Flat-Sided Solid Shapes Material." *JKPM (Journal of Mathematics Education Studies)*, vol. 7, no. 2, 2022, p. 289, https://doi.org/10.30998/jkpm.v7i2.12839.

Bagus, Krishna Huda, et al. "Development of Android-Based Learning Media Using Augmented Reality on the Material of Flat-Sided Spatial Buildings." *Journal of Mathematics and Science Education*, vol. 6, no. 1, 2018, pp. 61–69, https://journal.uny.ac.id/index.php/jpms/article/view/20551.

Balandin, S., Oliver, I., Boldyrev, S., Smirnov, A., Shilov, N., & Kashevnik, A. (2010). Multimedia services on top of M3 Smart Spaces. *Proceedings - 2010 IEEE Region 8 International Conference on Computational Technologies in Electrical and Electronics Engineering, SIBIRCON-2010*, *13* (2), 728–732. https://doi.org/10.1109/SIBIRCON.2010.5555154

Bower, M., Howe, C., McCredie, N., Robinson, A., & Grover, D. (2014). Augmented Reality in education - cases, places and potentials. *Educational Media International*, *51* (1), 1–15. https://doi.org/10.1080/09523987.2014.889400

Chen, Y. C. (2019). Effect of Mobile Augmented Reality on Learning Performance, Motivation, and Math Anxiety in a Math Course. *Journal of Educational Computing Research*, *57* (7), 1695–1722. https://doi.org/10.1177/0735633119854036

Estapa, A., & Nadolny, L. (2015). The Effect of an Augmented Reality Enhanced Mathematics Lesson on Student Achievement and Motivation. *Journal of STEM Education*, *16*(3), 40–49.

Khairunnisa, Shafa, and Tian Abdul Aziz. "Literature Study: Digitization of the World of Education Using Augmented Reality Technology in Mathematics Learning." *Jakarta Mathematics Education Research Journal*, vol. 3, no. 2, 2021, pp. 53–62, https://doi.org/10.21009/jrpmj.v3i2.22267.

Meilindawati, Riski, et al. "Application of Augmented Reality (AR) Learning Media in Mathematics Learning." *JURNAL E-DuMath*, vol. 9, no. 1, 2023, pp. 55–62,

https://doi.org/10.52657/je.v9i1.1941.

Nurfaidah, Nurfaidah, et al. “Systematic Literature Review: The Use of Augmented Reality (AR) in Mathematics Learning.” *Prisma*, vol. 12, no. 2, 2023, p. 380, https://doi.org/10.35194/jp.v12i2.3291.

Pangestu, A., Susanti, E., & ... (2019). Utilization of augmented reality (AR)-based learning media in students' spatial reasoning. *Proceedings of Seminar ...*, *5*(1), 88–93. http://prosiding.himatikauny.org/index.php/prosidinglsm/article/view/39

Purwodani, D. L., & Praherdhiono, H. (2018). Prospects for the Development of Digital Learning Environments for Generation Z in the Industry IV Era. *Journal of Education*, *3*, 930–934.

Saputra, Muhammad Reza, et al. "Implementation of Augmented Reality in Mathematics Learning Media for Recognizing 3D Shapes Using the Markerless Tracking Method." *Proceedings of the UNIMUS National Seminar*, no. Mdlc, 2023, pp. 954–67.

Setyorini. (2020). Towards the Learning Process in Curriculum 13? *Jiemar*, *01*(June), 95–102.

Syahida, E., Suprakarti, & Hadiyan, A. (2020). Development of Mathematics Learning Media Using Android-Based Smartphones with Augmented Reality Technology in Coordinate System Material for Grade VIII Junior High School. *Proceedings of the National Conference on Mathematics Research and Learning (KNPMP) V*, 72–84.

Wulandari, R., Widodo, A., & Diana, R. (2020). The Use of Augmented Reality Applications to Facilitate Students' Mastery of Concepts and Creative Thinking Skills. *Journal of Biology Education*, *11*(2), 59–69. https://doi.org/http://dx.doi.org/10.17977/um052v11i2p59-69

You, S., & Neumann, U. (2010). Mobile augmented reality for enhancing E-learning and E-business. *International Conference on Internet Technology and Applications, ITAP 2010 - Proceedings*, 1–4. https://doi.org/10.1109/ITAPP.2010.5566168