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The potential of 3d augmented reality book-based cell learning media to support educational transformation

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A B S T R A C T

Augmented Reality Book is a learning media that utilizes metaverse technology to convert 2D objects into 3D, as an educational transformation in the era of the industrial revolution 4.0. This innovation aims to facilitate students in understanding cell material more deeply and thoroughly. This study aims to analyze the use, utilization, and influence of 3D Augmented Reality Book-based learning media in supporting educational transformation in the era of the industrial revolution 4.0, as well as to determine its impact on students' understanding of cell material. The method used in this research is a literature study, by collecting data and information from various references, such as international and national journals, scientific articles, theses, news, official websites of institutions, and other supporting documents. The secondary data collected is then analyzed to produce the conclusion that the use of 3D Augmented Reality Book can help students understand cell material thoroughly

INTRODUCTION

Participants Learners have various characteristics, ranging from differences in knowledge and attitudes to skills. These differences in characteristics can affect the way learners, which in turn causes many of them to experience difficulties in understanding material. Learning difficulties are a condition of deviation between the ability possessed and the achievement, characterized by the presence of obstacles in the learning process (Zega & Zebua, 2023)**.** Results from various research studies related to students' learning difficulties show that this is due to the fact that they do not receive appropriate assistance in overcoming the problems they experience (Saidillah, 2018). As a step to overcome these problems, education needs to provide appropriate assistance to help students overcome obstacles in the learning process.

As a science, biology comes with complex discussions. Biology studies life on many levels, from molecular processes in cells to ecosystems, so it is important to learn (van Joolingen et al., 2021). It is recommended that learning be structured in stages, starting from simple structures to complex structures (Setiawan, 2019). As in cell matter, its microscopic size makes it difficult to understand this material. The images presented in this material are not presented in detail and detail from various perspectives, making it difficult to study cell material, especially looking at the characteristics of its cell structure (Lino Padang et al., 2022). Supposedly, the images presented must be designed in the form of three-dimensional (3D) animation to make it easier for students to master a cell material, especially cell structure. According to Edgar Dale's Cone of experience, observation activities can increase students' understanding of what is being learned by 50% (Padang et al., 2022). The images of the observation results can be presented in the form of learning media.

One of the supporters of the sustainability of the learning process in the classroom is learning media (Miftah, 2014). The teaching and learning process will be successful if the learning media used is appropriate and able to adapt to the development of science and technology (Yanto, 2019). Therefore, the selection of media is one of the crucial aspects of the teaching and learning process in the classroom (Aghni, 2018). The use of learning media can increase the efficiency of the teaching and learning process and strengthen positive interactions between teachers and students (Tafonao, 2018). One example is the use of Metaverse-based learning media. The metaverse allows users to interact and learn in a virtual environment that resembles the real world, thus providing a more immersive and engaging learning experience (Johan, 2022). The Metaverse has now begun to be applied in the education sector because the Metaverse combines the real world and the virtual world in 3D virtual form using Augmented Reality technology (Iswanto et al., 2022). In the world of education, the Metaverse is also an inseparable means of learning (Mulati, 2022). There are four types of simulations in Metaverse technology, namely Augmented Reality, Lifelogging, Mirror World, and Virtual Reality. Augmented Reality has a role in transforming 2D displays into 3D animations. The use of three-dimensional animation media can also improve learning outcomes, attitudes, behaviors, and learning effectiveness in students (Cahyani, 2020).

3D animation media also has advantages, including being able to display objects as a whole from various points of view so that it can create direct and memorable experiences for students, 3D media also has more elements that are more realistic and can be used repeatedly so that it can spark a sense of enthusiasm an motivation for learning in students (Aripin & Suryaningsih, 2019) The application of Augmented Reality in biology can provide students with an experience to explore materials that are less detailed and detailed (Stojšić et al., 2022). The presence of digital technology affects human life around the world in line with the development of the industrial revolution 4.0 (Harahap, 2019).

Today, the world has developed with the era of the industrial revolution 4.0 such as increased connectivity, interaction systems between humans, the development of technology in this era has caused almost everything to be done digitally, this has an impact on the development of learning media where currently learning media is not only in the form of books, but can be packaged in digital form (Bagus Kurniawan & Sumari, n.d.) Technological developments will certainly have a wide impact on humans psychologically, socially, and biologically (Adiansah et al., 2019). However, this era will disrupt various human activities in various fields, not only in the field of technology (Trisyanti & Prasetyo, 2018). One of them is the field of education in Indonesia (Doringin et al., 2020). To meet the needs in facing developments in the industrial revolution 4.0, it is necessary to take a step in aligning human work with technological functions in creating new opportunities and opportunities with creative ideas and evidenced by innovations (Doringin et al., 2020). For this reason, the development of AR learning

media is an innovative step that needs to be taken in supporting the learning of cell material, AR media can visualize the shape and characteristics of abstract cells so that it can help students who have difficulty understanding this material, AR can help students gain a deep understanding of the shape and characteristics of cells (Khanan et al., 2024)

Aligning work with technological functions must be carried out by teachers to be able to survive in the era of the industrial revolution. In this digital era, a teacher should have a paradigm that is closely related to the use of technology in supporting learning (Jayawardana, 2017). Based on articles indexed by Google Scholar, with the use of Augmented Reality by biology educators, especially for cell material from 2014 to 2024 based on articles indexed by Google Scholar by utilizing the Harzing's Publish or Perish application, it is known that no one has packaged it in the form of a 3D Augmented Reality book. . Several previous studies such as Purnamasari et al., (2016), Saputra et al., (2023), Ummah et al., (2024), Kafilahudin & Akbar (2024), Rabani & Zakariyah (2024), and Azrai et al., (2024) package the use of Augmented Reality in biology learning by using cameras to scan barcodes so that 3D media visualization appears. Furthermore, Wiguna et al., (2020), Indahsari et al., (2021), and Rahmawati et al., (2022). Packaging Augmented Reality in Applied Biology Learning. Based on this description, this study aims to determine the potential of learning media in cell material in the form of 3D Augmented Reality books as an educational transformation in the era of the industrial revolution 4.0. The general description of the 3D Augmented Reality book is to use books as the main medium that is specially designed to be able to see 2D objects to look at 3D from various perspectives. As is known, in cell material, some images are less detailed. Therefore, the presence of 3D learning media based on the Augmented Reality book application in the field of education is expected to provide a more detailed representation of objects in 3D form, making it easier for students to understand cell material.

METHODS
Research Design

This research uses the literature study method, which includes collecting library data, reading, recording, and managing data objectively, systematically, analytically, and critically according to the topic under study, namely 3D Augmented Reality, especially cell material in biology learning. The data collected is in the form of secondary data by taking scientific article data on the internet, reading, recording, and processing research materials from research articles related to these research variables. The selected data sources come from articles published in accredited national and international journals that used the research and development method based on predefined keywords.

Procedure

The literature study was carried out by collecting references related to previous research from databases such as Google Scholar, publish or Perish, and other search engines, with the keywords " 3D Augmented Reality", "cell learning media", and "augmented reality on cell material". Articles selected were articles that met the inclusion criteria, including articles published in indexed journals, discussing the topic of the influence of 3d augmented reality learning media on cell material in biology subjects published in the last 10 years (2014-2024) to ensure up-to-date information on the topic. The data from the selected articles are then compiled to conclude the potential of learning media in cell material in the form of 3D Augmented Reality books as an educational transformation in the era of the industrial revolution 4.0. The procedure in the research starts from 1) choosing a theme; 2) information exploration; 3) determination of research direction; 4) collecting data sources; 5) data presentation; and 6) the preparation of reports (Dunford, 2003).
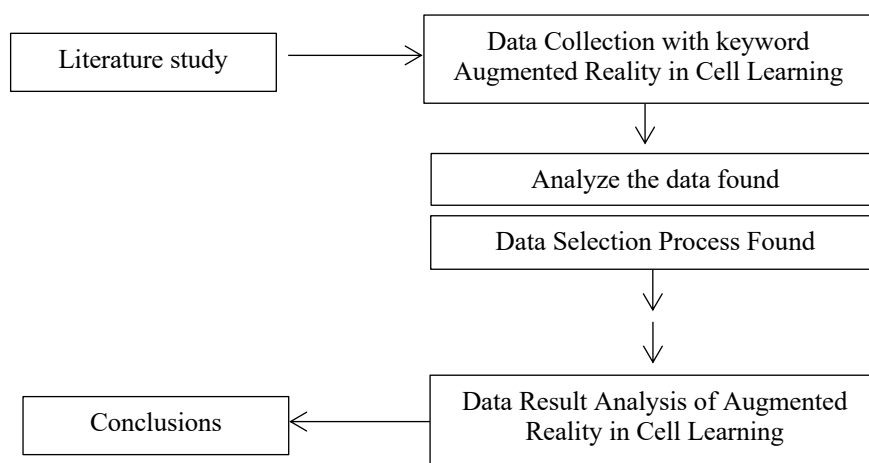
Figure 1. Research Stage

Data Analysis Techniques

The data analysis technique used was content analysis. The results of the research were analysed starting from the most relevant, relevant, and quite relevant based on the topic under study, which is about 3D augmented reality media and its effect on learning cell material. The research continued by analysing the year of research from the latest to the previous year, then coding was done by categorising the content of the articles analysed, such as the research methods used, the use of augmented 3D as a learning medium, and the effect of using 3D media on student learning outcomes in cell material. The collected data will be projected into learning media in the form of three-dimensional (3D) Augmented Reality book applications that can visualise the shape of living cells in 3D.

RESULTS AND DISCUSSION

The occurrence of changes in technological advances in the world in the era of the industrial revolution is something that must always be studied and anticipated for its impact on human life, it is inseparable from the world of education also feels the impact of these changes, in this case the transformation of education with the advancement of technological innovation is urgently needed to be able to adapt to the advancement of technology in the era of the industrial revolution 4.0. Breakthroughs have begun to be intensified to advance and improve the quality of education so that it is always up to date and follows the flow of technological transformation, especially in the field of Mathematics and Natural Sciences (MIPA). Currently, there is already a learning media by utilizing the metaverse world, which in its implementation is all-digital by producing a reality and visualization of abstract concepts in the field of Mathematics and Natural Sciences, one of which is the use of Augmented Reality technology as a learning medium to help students understand a material more easily.

Table 1.
The results of the study are related to Augmented Reality in cell learning

Author(s) & Year	research objectives	Result
Haryanto et al, (2017)	To determine the implementation of Augmented Reality and its effect on student learning outcomes.	Marker testing as many as 10 were detected and 6 were not detected, all features worked well and after the test was carried out, the results of the pre and post test showed an increase from an average score of 33.33 to a value of 52.66, but there was 1 student who had a fixed score due to lack of motivation.
(Pambudi & Rahmi, 2022)	Provide knowledge about parts of cell organelles in plants and animals that use Augmented Reality (AR) to students at SMA Negeri 1 Dlingo.	The application features are appropriate and can display 3D objects of plant and animal cells and have additional features that support, can be applied with smartphones and after testing the application can be used to help the learning process so that respondents agree that Augmented Reality can help learn cell organelles in animal and plant cells.
(Padang et al., 2022)	To know the improvement of the learning outcomes of	The value of grade VII students in the material of the organization system of living things with Assemblr

Author(s) & Year	research objectives	Result
	seventh grade students on the material of the organizational system of living things that are taught using Assemblr EDU media based on Augmented Reality.	EDU media based on Augmented Reality, it can be seen that the value (N-Gain) shows a score of 0.25 which shows an increase but is still included in the low category, although it can still be said that the application of the media has a good influence in the form of increasing the results of class VII students.
(Peterson et al., 2020)	Exploration of the use of augmented reality (AR) as an additional tool in teaching molecular visualization and improving visual literacy.	AR can increase interest in learning biomolecular material because it is able to visualize the 3D structure of proteins well. The questionnaire results showed that 89% of respondents stated that AR helped their understanding of protein structure. In addition, there are drawbacks to AR, especially software problems that are too expencive and sometime the software are slow or difficult to use
(Khanan et al., 2024)	To knowing the feasibility level of the application of Cell Biology Augmented Reality (BIOSAR) based on android as a learning medium in class XI SMA / MA. (BIOSAR) application based on android as a learning medium in class XI SMA / MA.	This AR-based BIOSAR application is proven to be valid and practical to use, has the potential to facilitate student understanding of abstract structural material, so that interesting learning can increase student interest in learning. this application is feasible to implement in learning cell material. However, the shortcomings of this application have not been able to display cell details in detail and have not supported platforms other than android.

The results of the first research show that the design of the Augmented Reality application is appropriate, the application is able to visualize plant cells and animal cells in three-dimensional (3D) form well, several features such as the scan menu, main menu page, info page, setting features, quiz page and pop up cells can be displayed properly with the operation of a smartphone as a tool for use. These complete and well-functioning features can help the learning process as a support for understanding plant and animal cell material in learning media using books (Angga et al., 2022). This is seen from the results of a questionnaire that showed that respondents agreed that AR can help learn animal and plant cell organelles. The results of the second research showed that the application test on 16 markers in the class XI biology learning book cell division material resulted in 10 markers detected and 6 markers not detected. This is due to several factors that occur at the time of testing, namely, the image size is too small so that it lacks good texture, and the lighting during scanning causes the testing process to run poorly.

However, some of the features displayed on the application can run well when the test takes place (Haryanto et al., 2017). After conducting a pre-test and post-test, which was tested on a group of students who studied with textbooks, the average score increased. Based on the results of the test, learning media using applications has improved because learning is more interesting when done by adding 3D objects and interesting animations for students (Cahyani, 2020). The results of the third research show that when students work on the Student Worksheet (LKPD) with the help of the use of learning media in the form of the Assemblr EDU application based on Augmented Reality in learning the organization system of living things which is tested to 3 classes at the high school level grade VII. The results of the study showed that there was an increase in pre-test and post test results, where class VII.6 had an increase in learning outcomes from an average score of 12.14 to a score of 15.36, class VII.7 experienced an increase in learning outcomes from an average score of 12.02 to a score of 17.47 so that it can be concluded that the three classes experienced an increase in learning outcomes after using the learning media of the Assemblr EDU application based on Augmented Reality on organizational system materials the life of living beings (Lino Padang et al., 2022).

However, even so, the increase in learning outcomes is still said to be at a low level because, based on research results by Padang et al, (2022), the calculation of the average score (N-Gain) shows a score of 0.25. Several studies that have been carried out have obtained results that the use of Augmented Reality application-based learning media provides an improvement in students' learning outcomes in cell material. This is because the features of the application can support learning and help millennial students to more easily understand abstract Biology learning (Stojšić et al., 2022). This technology can

provide realistic visualization of abstract concepts so that they can be easily understood (van Joolingen et al., 2021). In addition, the presence of unique and interesting features gives a pleasant impression when learning so that students have higher motivation to continue learning and exploring their knowledge (Andis Indrawan et al., 2021). This media is also in accordance with the characteristics of millennial generation students in the era of the industrial revolution 4.0 with the use of technology because it can facilitate daily life (Hidayatullah et al., 2018).

Several studies show an increase in the low stage, which is influenced by several factors, including the quality of the applications made, the ability of smartphones to run applications, and external factors such as lack of lighting, lack of texture in images, and so on (Lino Padang et al., 2022). so according to research (Khanan et al., 2024), further development is needed to be able to maximize existing features to display more detailed and clear cell shapes and characters. Augmented Reality technology, which is included in the Metaverse world, has a great contribution to the transformation of the world of education, in this case, to the teaching and learning process in schools (Maritsa et al., 2021). This is because the media used can bring breakthroughs in a modern and unique way that creates a more fun and informative learning atmosphere by visualizing abstract concepts that are usually in the form of 2D into 3D (Cahyani, 2020).

In this study, there are limited reference sources where research articles on the development of AR as learning media are still very limited so that this has an impact on the narrowness of the discussion space, this allows many things that have not been explored properly related to perspectives, methodologies and also experimental findings in the field, for this reason further research on the relationship between methodology and various forms of AR as learning media for cell material with student learning outcomes needs to be done.

CONCLUSION

The use of three-dimensional (3D) Augmented Reality book learning media based on a literature review has the potential to help students to understand cell material more thoroughly with the help of features that can provide clear, realistic visualization. Thus, students can understand the differences in cell shape of a living being. This form of 3D animation can also help students to understand the material more easily so that this technology can support learning outcomes in students. Various data that have been taken show that students are helped by the breakthrough in the use of this learning media. However, the development of AR media is also still very much needed to be done to be able to increase the level of effectiveness and usefulness in supporting learning, There needs to be a more in-depth study to be able to compare various forms of AR media and their relation to improving student learning outcomes. The research conducted can produce a change in learning improvement, especially in terms of learning media in schools as a breakthrough in the transformation of education with the development of technological innovation.

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