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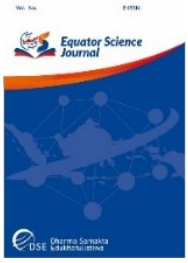

Development of Science Teaching Materials Based on Augmented Reality on Energy Material in Living Systems

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ABSTRACT
The nature of Natural Science as a science that originates from nature and has several abstract concepts that cannot be presented directly into the classroom is a challenge for teachers to convey these concepts. The rapid development of technology allows humans to interact directly without being limited by space and time. One technology that can be used to visualize several abstract concepts in science lessons is augmented reality. This study aims to develop science teaching materials based on Augmented Reality (AR) on the material of energy in life systems. This type of research is development research referring to the development of Borg & Gall which was modified from (Sugiyono, 2014). This study consists of 10 stages, namely (1) Potential and Problems; (2) Data Collection; (3) Product Design; (4) Product Design Validation; (5) Product Design Revision; (6) Product Trial; (7) Product Revision; (8) Usage Trial; (9) Product Revision; and (10) Mass Production. By implementing all these stages, it is expected to produce science teaching materials based on Augmented Reality that are valid and reliable based on expert responses and trial results. The output of this study is a research article published in an accredited national journal and HAKI science teaching materials based on Augmented Reality.

INTRODUCTION

Education is a very essential aspect that should be a right for every individual. Education is desired in order to direct a person to live life with a foundation of knowledge and have the ability to overcome surrounding problems with creative and innovative ideas (Mardhiyah et al., 2021). According to Law No. 20 of 2003, education is a conscious and planned effort to create a learning atmosphere and learning process so that students actively develop their potential to have religious spiritual strength, self-control, personality, intelligence, noble character, and skills needed by themselves, society, nation and state. Thus, the development of students' potential is highly dependent on the successful implementation of the education system, especially in classroom learning.

The education system must be responsive to changes in the dynamics of national life that currently require adaptation in various sectors, including in facing the challenges of globalisation that are happening in the world. Today, the ever-evolving technology has reached the digital phase (Hidayat et al., 2024). Even in Indonesia, various sectors have started to utilise technology to simplify work processes, including in the field of education. Rosentbeg (Huda, 2020), there are five shifts in the learning process along with the development of the use of technology in education, namely: (1) from training to performance, (2) from classroom to emphasis on where and when, (3) from cycle time to real-time, (4) from offline to online, and (5) from physical facilities to virtual facilities.

One of the virtual technologies that can be used in learning is Augmented Reality (AR) based technology. AR is a technology in which virtual objects produced by computers are physically displayed in the real world (Ozdemir et al., 2018). With the help of this technology, learners can observe objects directly using various colours. The use of this technology also looks more interesting without reducing the substance of the material (Syawaludin & Rintayati, 2019). The learning process must be interactive and able to motivate students (Almaghfira et al., 2024), while teachers as learning facilitators must be proactive in creating a lively learning atmosphere (Nurharini et al., 2024). In this case, supporting media that supports learning becomes important. This media is effective and efficient in supporting millennial learners in the digital technology-based learning process.

Teaching materials have become an integral part of learning in today's modern education era. According to Husnaini et al., (2023), the ability of Augmented Reality can attract learners by presenting the context of the real environment in the virtual world. This technology can be used to visualise abstract concepts beyond the reach of human senses in some materials in Natural Science (IPA) lessons. The use of AR technology also inspires students to learn actively and enhance their creativity. It allows students to engage in virtual experiments, observe the results, and even create their own experimental designs. In more detail, the use of AR in learning attracts students' attention so that they have a better chance of retaining the information and concepts they learn (Hikmah & Ningsih, 2023). The utilisation of this technology presents a more interactive and immersive learning experience.

Based on the description above, the development of AR-based digital learning materials for science subjects is an innovative step to facilitate students' understanding of scientific concepts better and provide a solid foundation to face challenges in the fields of education and technology that continue to grow in the future.

METHOD

This research was conducted using the research and development method or in English research and development. The research and development method is a research method used to produce certain products, and test the effectiveness of these products (Wicaksana, 2020). In this research and development method, researchers refer to the Borg & Gall development model modified from (Sugiyono, 2014). The development research flow chart according to Sugiyono (2014) can be seen in Figure 1.

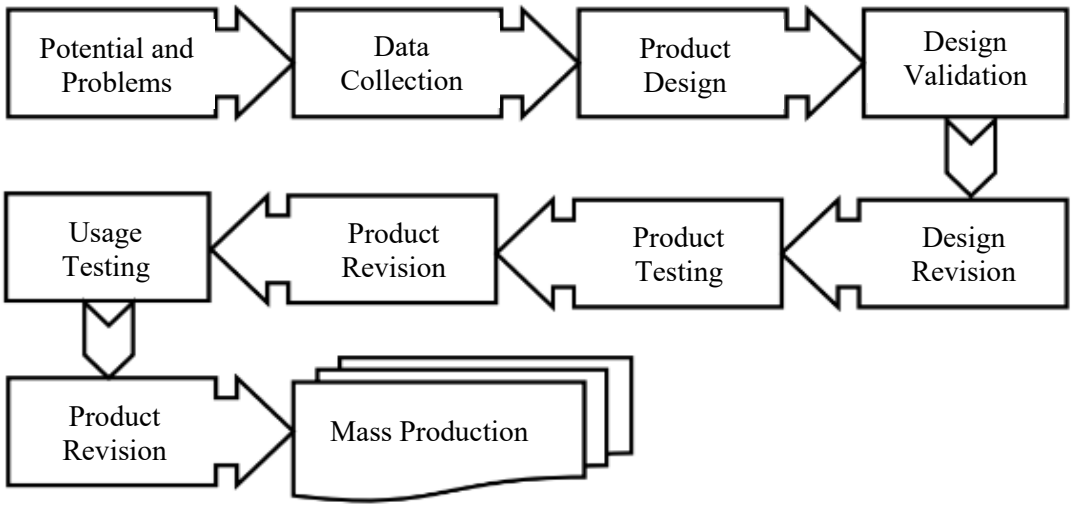

Figure 1. Flowchart of development research

In this development research, the steps taken follow the stages outlined by Sugiyono (2014). The process begins with identifying potential and problems that serve as the foundation of the research. These potential and problems can be obtained from various sources, such as previous research reports or documentation of activities from relevant individuals or institutions. Once the problems and potential are factually and accurately identified, data collection is conducted to gather information that can serve as a basis for planning a product aimed at addressing the identified issues.

The next stage is product design, which in this case involves the development of augmented reality-based digital science teaching materials. These materials are designed in the form of images or diagrams to serve as guidelines for assessment and creation. To ensure the reliability of the product, design validation is carried out by involving experienced experts who assess its feasibility and validity. Following validation, revisions are made based on expert feedback to address any weaknesses in the design.

After the revisions, a limited product trial is conducted to evaluate the effectiveness and efficiency of the augmented reality-based teaching materials. Based on the results of the trial and further expert input, additional revisions are made to refine the product and eliminate any remaining shortcomings. Once the revised product successfully passes testing, it is implemented in real-world conditions on a broader scale through trial use. If any deficiencies are identified during this stage, further revisions are made to enhance the product's quality.

Finally, once all stages have been successfully completed and the product is deemed effective and feasible, mass production can proceed. This ensures that the augmented reality-based digital science teaching materials can be widely distributed and utilized to support a more innovative and interactive learning experience.

RESULTS AND DISCUSSIONS

This research was conducted at MTS Muhammadiyah Al-haq Palu from April to October 2024. The results obtained at each stage of the research are as follows:

Potential and Problems

Based on the observation on 31 July 2024, it was found that the school has adequate learning facilities, such as the availability of projectors in each class, internet access points that can be reached by teachers and students, and all students have smartphones that can be used to access online learning resources. However, the utilization of the latest learning media at school remains minimal. These findings align with previous research by Husnaini et al. (2023), who emphasized that the availability of technology infrastructure does not necessarily translate into its effective use in the classroom. The potential for integrating augmented reality (AR)-based teaching materials is significant, especially

considering that AR has been demonstrated to enhance student engagement and learning outcomes (Mufida et al., 2021).

Data Collection

At this stage, data collection was carried out through a socialization activity for AR-based science teaching materials on 14 August 2024. Participants included teachers and students at MTS Muhammadiyah Al-haq Palu. Teachers expressed the need for AR learning media that facilitates explanations of energy conversion, particularly in the case of hydropower plants (PLTA) in Central Sulawesi. Previous studies, such as those by Fitriyah et al. (2022), support this need, showing that AR-based learning media is particularly effective in presenting abstract scientific concepts. Additionally, teachers emphasized the importance of offline accessibility, consistent with findings from Nengsih et al. (2023), who noted that one of the challenges in implementing AR is the dependency on stable internet access.

Product Design

Based on the collected data, researchers developed an AR-based learning medium using the Assemblr Edu platform. This platform was chosen due to its ease of use, storage efficiency, and accessibility through QR codes. Similar approaches were used in research by Izdihar et al. (2024), who highlighted the advantage of AR applications in reducing cognitive load by integrating multiple media formats, such as 2D and 3D images, audio, and text. The developed media specifically focused on the energy transformation process in hydropower plants, aiming to provide a more interactive and immersive learning experience.

Design Validation

The learning media design was validated by a media expert and a material expert. Media experts found the design effective, though they suggested improvements in object coloring for realism. The validation score of 88.7% aligns with prior studies by Izdihar et al. (2024), where AR-based materials received high validation ratings above 90%. Similarly, material experts found the content well-structured but recommended improvements in mathematical equation formatting. Their validation score of 92.3% further corroborates the findings of Fitriyah et al. (2022), who reported similar validation results for AR-based educational tools.

Product Trial and Revision

A limited product trial was conducted to gather student feedback. Students successfully accessed the AR media but encountered delays in object rendering due to high-resolution assets. This aligns with Husnaini et al. (2023), who identified technical challenges in AR-based education, particularly concerning device performance and optimization. Researchers addressed this issue by reducing object resolution while maintaining visual quality. Additionally, feedback from students suggested the inclusion of an active button for direct navigation to the evaluation menu, a feature that has been recommended in previous AR usability studies (Nengsih et al., 2023).

Trial of Use

A larger-scale implementation was conducted through a workshop on 14 September 2024, involving teachers and students. A pre-test and post-test analysis indicated significant improvements in students' understanding of energy transformation concepts. The t-test analysis showed a statistically significant increase in students' scores, supporting previous findings by Husnaini et al. (2023), where AR-based learning achieved a 66.7% effectiveness rating in student learning assessments. Moreover, students reported high levels of engagement, consistent with studies by Mufida et al. (2021), which highlighted AR’s role in increasing motivation and interaction in science learning.

Final Revisions and Mass Production

Based on student and teacher feedback, the final revision included the addition of a navigation button for assessment access. After the revisions, the learning media was handed over to teachers for integration into classroom instruction. Similar implementation strategies have been observed in other studies, where AR-based science materials were adopted for long-term classroom use with positive

reception (Fitriyah et al., 2022). While this study demonstrated the feasibility and effectiveness of AR in science education, challenges such as technological limitations and teacher readiness remain areas for further investigation.

This study contributes to the growing body of research on AR-based learning by focusing on hydropower energy transformation, a topic that has not been extensively covered in previous studies. While prior research (Husnaini et al., 2023; Fitriyah et al., 2022) has validated the effectiveness of AR in improving science education, this study extends the application to a specific regional context, addressing real-world issues such as electricity shortages in Central Sulawesi. Additionally, this study highlights practical challenges related to media optimization and accessibility, which have been underexplored in the existing literature. Future research should explore long-term retention effects and scalability of AR-based learning in different educational settings.

CONCLUSION AND SUGGESTION

Based on the results of the research conducted, it can be concluded that the developed learning media is valid and reliable and can improve students' learning outcomes. A suggestion for future research is to develop learning media for other subjects, particularly those with essential concepts, to further facilitate classroom learning.

REFERENCES

Almagfira, A., Alibasyahi, L., & Agni, R. (2024). The effect of cooperative learning model of teams game tournament type on motivation and learning outcomes of junior high school students in Palu. *Equator Science Journal, 2*(2), 58–64. https://doi.org/10.61142/esj.v2i2.126

Fitriyah, I. J., Marsuki, M. F., & Affriyenni, Y. (2022). Development of augmented reality-based learning materials on redox reaction materials for students in basic chemistry II course. *Nucleation and Atmospheric Aerosols*. https://doi.org/10.1063/5.0112726

Hidayat, A. N., Machmudin, D., & Soesilawaty, S. A. (2024). The effect of mobile learning on excretion system materials on cognitive load and student concept mastery. *Equator Science Journal*, *2*(1), 21–30. https://doi.org/10.61142/esj.v2i1.115

Huda, I. A. (2020). Perkembangan teknologi informasi dan komunikasi (TIK) terhadap kualitas pembelajaran di sekolah dasar. *Jurnal Pendidikan dan Konseling*, 121–125. https://doi.org/10.31004/jpdk.v1i2.622

Husnaini, H., Nurhikmah, H., Muin, A., & Hakim, A. (2023). Development of teaching materials based on augmented reality (ar) in science subjects at min 1 kolaka utara students. *Auladuna: Jurnal Pendidikan Dasar Islam*, *10*(2), 224–232. https://doi.org/10.24252/auladuna.v10i2a8.2023

Izdihar, D., Liliawati, W., Danawan, A., & Sasmita, D. (2024). Development of E-Modules Assisted By Augmented Reality on Alternative Energy Material. *Jurnal Penelitian Pembelajaran Fisika*. https://doi.org/10.26877/jp2f.v15i4.961

Mardhiyah, R. H., Aldriani, S. N. F., Chitta, F., & Zulfikar, M. R. (2021). Pentingnya keterampilan belajar di abad 21 sebagai tuntutan dalam pengembangan sumber daya manusia. *Lectura: Jurnal Pendidikan*, 29–40. https://doi.org/10.31849/lectura.v12i1.5813

Mufida, Z., Parno, P., & Marsuki, M. F. (2021). *Development of science teaching materials using inquiry based learning model enhanced augmented reality on elements, compounds, and mixtures topics to develop critical thinking skills of class vii smp students*. *5*(1), 7–11. https://doi.org/10.17977/UM033V5I1P7-11

Nengsih, N., Setiadi, A. E., & Sunandar, A. (2023). Development of augmented reality learning media based on assemblr studio web in ecosystem material. *Jurnal Inovasi Pembelajaran*. https://doi.org/10.22219/jinop.v9i2.25251

Nurharini, F., Muaziyah, S. E. S., & Shidqiyyah, N. (2024). Implementation of educational innovations in student management, facilities, curriculum, and public relations in integrated science-social

studies learning at MI Al-Islamiyah Bangil: A case study. *Equator Science Journal, 2*(3), 149–154. https://doi.org/10.61142/esj.v2i3.160

Ozdemir, M., Sahin, C., Arxagok, S., & Demir, M. K. (2018). The effect of augmented reality applications in the learning process: A meta-analysis study. *Eurasian Journal of Educational Research*, 165–186. https://doi.org/10.14689/ejer.2018.74.9

Pauls, A., & Karsakov, A. (2021). The concept of using augmented reality technology to present interactive calligraphic objects. *Procedia Computer Science, 193*, 407–414. https://doi.org/10.1016/j.procs.2021.10.042

Safitri, H. A., & Wulandari, M. D. (2023). Digital tale media to improve the emotional intelligence of elementary school. *AULADUNA: Jurnal Pendidikan Dasar Islam, 10*(1), 75–85. https://doi.org/10.24252/auladuna.v10i1a6.2023

Sugiyono. (2014). *Metode penelitian kuantitatif, kualitatif, dan R & D*. Alfabeta.

Syawaludin, A., & Rintayati. (2019). Development of augmented reality-based interactive multimedia to improve critical thinking skills in science learning. *International Journal of Instruction*, 331–344. https://doi.org/10.29333/iji.2019.12421a

Wicaksana, M. F. (2020). *Belajar mengembangkan model penilaian autentik*. Deepublish.