



# Development of Science Teaching Materials Assisted by Augmented Reality to Improve Students' Ability in V Grade

Firstyansa Heriyanto<sup>1</sup>, Eka Titi Andaryani<sup>1\*</sup>

<sup>1</sup>Elementary School Teacher Education, Faculty of Education and Psychology, State University of Semarang, Indonesia.

Received: January 24, 2026

Revised: May 24, 2026

Accepted: June 25, 2026

Published: June 30, 2026

Corresponding Author:

Eka Titi Andaryani

[ekatitiandaryani@mail.unnes.ac.id](mailto:ekatitiandaryani@mail.unnes.ac.id)

DOI: [10.29303/jppipa.v12i6.14384](https://doi.org/10.29303/jppipa.v12i6.14384)

 Open Access

© 2026 The Authors. This article is distributed under a (CC-BY License)



**Abstract:** This study aims to determine how Augmented Reality Teaching Materials can improve students' understanding and skills, given that students initially had difficulty understanding the material because the teaching method used was still the old method, commonly known as the lecture method. Here, the researcher presents a new learning concept, namely using a learning method in which students are actively involved in learning. The researcher uses the ADDIE research method, in which this research begins with At this stage, initial observations were conducted at SDN Podorejo 02, with m pages and classrooms, and a direct meeting with the principal. Next, communication with the fifth-grade homeroom teacher about IPAS subjects. The researcher analyzed how fifth-grade, After conducting an analysis and identifying the problems from the school's analysis, the researcher attempted to design and create a highly interactive learning medium that follows technological developments to replace the old learning method, which only used thick printed books and lectures, Next, for this stage, the development product is ready to be created according to the plan made by the researcher; learning media is prepared, and media is created. Media experts and material experts in their fields are also referred to as teachers, whose job is to guide and check whether the material from the media complies with existing regulations to ensure its validity. After conducting a series of tests through media experts and after going through the revision stage, the next step is to implement the media to students to see whether or not this learning media can improve student learning outcomes. After implementing the media created at Podorejo 02 Public Elementary School, the next step is to evaluate the results of the implementation which involves conducting a formative and summative evaluation to measure whether this media can improve student learning outcomes in Grade V IPAS lessons. And then this conclusion this Based on the results of the research and discussion of teaching materials assisted by Augmented Reality in IPAS lessons at Podorejo 02 Public Elementary School, the following conclusions can be drawn: Development of teaching materials assisted by Augmented Reality in IPAS lessons at Podorejo 02 Public Elementary School using the ADDIE method on the Assemblr Edu website, which shows 3D and AR technology that functions as a teaching medium that can display the shape of objects or images in 3D. Based on the responses from the students, a score of 69% was obtained, indicating an increase from the initial stage where the students did not understand the material to the stage where they became familiar with it. Therefore, this medium is categorized as suitable for use.

**Keywords:** Augmented reality; Cultural diversity; E-teaching materials; Science

## Introduction

To ensure that the learning process is carried out effectively and supports the achievement of graduate

competency standards, it is necessary to develop process standards for early childhood education, primary education, and secondary education, as stipulated in the 2026 Regulation of the Minister of Primary and

### How to Cite:

Heriyanto, F., & Andaryani, E. T. (2026). Development of Science Teaching Materials Assisted by Augmented Reality to Improve Students' Ability in V Grade. *Jurnal Penelitian Pendidikan IPA*, 12(6), 395–403. <https://doi.org/10.29303/jppipa.v12i6.14384>

Secondary Education of the Republic of Indonesia. This law also serves as a basis for curriculum development and education implementation in Indonesia (Bagaskara et al., 2024). Education is the most important foundation in shaping character and developing one's potential. Education plays an important role in shaping the potential of each individual (Hidayah et al., 2024). Advances in science and technology also greatly influence several aspects of life, such as education. The influence of technology on education can also be seen from the increasingly adequate educational facilities available. Technology, which develops every day, will lead humans to come up with new, highly innovative ideas, one of which is technology in the field of education (Mulyadi et al., 2023; Munandar et al., 2024). This foundation plays a very important role in shaping a person's character (Majir, 2020; Rizqi et al., 2023).

In reality, technology has not been fully utilized in education (Doyan, Jufri, et al., 2020). One of the educational materials that greatly determines student achievement in this goal is the cultural diversity of Indonesia. This subject can provide students with an understanding of the rich culture that exists in Indonesia, for example, traditional houses, traditional clothing, regional dances, and the languages of each region. However, the delivery of this subject matter is still conventional and lacks interactivity, making it difficult for students to fully understand the concepts (Khasanah et al., 2019; Laksana, 2021).

The advancement of technology today has greatly influenced the field of education. One of the ways is by utilizing technology as teaching materials used in learning (Doyan, Gunawan, et al., 2020). These teaching materials include augmented reality to facilitate learning, where augmented reality is a technology used to teach material by technology that can display 3D images that can be viewed from the front, side, or back in real life (Dewi et al., 2021; Paulauskas et al., 2023).

Augmented Reality-assisted teaching materials have the potential to improve students' understanding of cultural concepts visually and contextually. This medium is very useful for increasing students' interest in learning, as students tend to be more active because they have never used Augmented Reality media before (Irmade et al., 2022; Maulida et al., 2025; Sari et al., 2022).

Considering this potential, the development of learning media that utilizes current technology, namely learning media assisted by augmented reality, is expected to enable students to interact and directly see cultural objects that have been created in 3D (Boboc et al., 2022; Pauziah et al., 2023; Xu et al., 2024).

Based on the above explanation, the researcher wants to try to redevelop technology-based learning media designed by the researcher using an application called Assemblr Edu, which will be developed as

interactive and enjoyable learning media. The researcher conducted this study with the title "Development of Augmented Reality-Assisted Teaching Materials for IPAS Subjects on Cultural Diversity for Grade V at Podorejo 02 Public Elementary School". This media is useful for explaining the forms and diversity of culture in Indonesia and assists in the use of 2-dimensional books, as this media is 3-dimensional, helping children see from the front, back, right side, and left side. With this learning media, it is hoped that the learning outcomes of students will improve

## Method

The approach used for this research is research and development (R&D) using a quantitative approach. The researcher developed one medium is teaching material in the form of a flipbook assisted by Augmented Reality (AR) intended for use in Podorejo 02 Elementary School, grade V. Research and development (R&D) is a research method that focuses on one area, namely product creation. It is used to create the latest innovative products when previous products are deemed unsuitable, to test the effectiveness of current products, and to create new products. The purpose of this research is to solve a problem that exists at SDN Podorejo 02, specifically in Grade 5 (Pauziah et al., 2023).

The current research uses is the ADDIE (Analysis, Design, Development, Implementation, and Final Evaluation) model developed by Robert Maribe Branch. The ADDIE model can be said to be accurate because the procedures for its implementation align with the steps of the R&D method currently in use (Oktaviara et al., 2019). The ADDIE method has five stages that must be carried out, including:

### *Analyze*

At this stage, initial observations were conducted at SDN Podorejo 02, with m pages and classrooms, and a direct meeting with the principal. Next, communication with the fifth-grade homeroom teacher about IPAS subjects. The researcher analyzed how fifth-grade learning performed using the old method, which was lecturing and writing objects on the blackboard. Then learning problems arose. This means that changing the learning method would be very good so that students can actively participate in class and be very interested in actively participating in learning, especially in IPAS subjects, particularly in fifth grade.

### *Design*

After conducting an analysis and identifying the problems from the school's analysis, the researcher attempted to design and create a highly interactive learning medium that follows technological

developments to replace the old learning method, which only used thick printed books and lectures.

Development

Next, for this stage, the development product is ready to be created according to the plan made by the researcher; learning media is prepared, and media is created. Media experts and material experts in their fields are also referred to as teachers, whose job is to guide and check whether the material from the media complies with existing regulations to ensure its validity.

Implementation

After conducting a series of tests through media experts and after going through the revision stage, the next step is to implement the media to students to see whether or not this learning media can improve student learning outcomes.

Evaluation

After implementing the media created at Podorejo 02 Public Elementary School, the next step is to evaluate the results of the implementation which involves conducting a formative and summative evaluation to measure whether this media can improve student learning outcomes in Grade V IPAS lessons (Lyanda et al., 2023).

Result and Discussion

Description of Research Results

From the interviews and observations conducted by the researcher with sixth-grade teachers, it was found that in IPAS lessons, particularly in the cultural studies section of social studies, there are still teaching methods that use old methods or lectures, which cause students to quickly become bored and unable to focus during lessons, so that many students play on their own during lessons. Because students are preoccupied with themselves, this has an impact on their understanding, where students become less understanding of the material being taught.

Because of this, the researcher tried something new, namely developing teaching materials and learning media that can encourage students to learn more actively, so that students do not get bored quickly and can understand the material well.

Discussion

Development

The initial stage carried out by researchers is to create a design plan that they will use later. After creating the plan, researchers then study its implementation with the help of the Assemblr Edu application/website.

The next stage is to collect several sources of material that can be used to create learning materials that will be used by researchers in creating teaching materials. Then, after the learning materials are created, the validator will evaluate the teaching materials and content created by the researchers. The purpose of validation is to determine whether the teaching materials and media created by the researcher can be applied in elementary schools. If they are not yet suitable, expert validators will direct the researcher to revise the teaching materials and media created by the researcher before they can be used in elementary schools.

Teaching Material Display Initial Display



Figure 1. Initial Display, a) Cover, b) Foreword, c) User guide, d) Table of contents, e) CP and TP, f) Concept map

This page contains information about the teaching materials that the researcher has created. The initial display includes the cover, foreword, user guide, table of contents, learning outcomes, learning objectives, and concept map. The author created this initial display with the aim of making it easier for teachers to find information about the teaching materials, which consist of several sections.

Material Display



Figure 2. Material display, a) Local culture material, b) National songs, c) Regional musical instruments, d) World-Recognized, e) National culture material, f) Preservation efforts

The material display is a display that contains the essence of the main purpose of this teaching material

book, where this material display contains material that will be taught to students. This material display contains material on regional culture, local culture, national culture, national music, regional music, and so on.

Closing Display

This closing page introduces the identity of the author of the teaching material. It contains a bibliography, the author's biography, and the cover of the book.



Figure 3. Closing display, a) Bibliography, b) Author biography, c) Author biography, d) Closing

Media Display



Figure 4. Home page

The initial page display shows the screen that teachers or students see when they first enter the Assemblr Edu website. This is the initial display where users enter the Assemblr Edu account they have created to log in to the Assemblr Edu website.

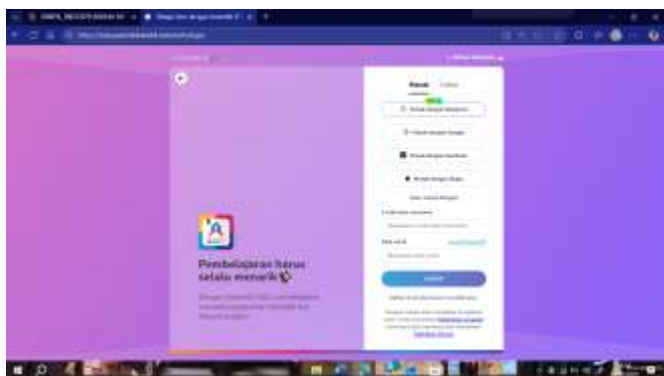


Figure 5. Login page display

The page above is the account login page. On this page, users are asked to enter the account they have created to access the Assemblr Edu website. They can log in in various ways, such as using a learning account, personal email, mobile phone number, and so on.

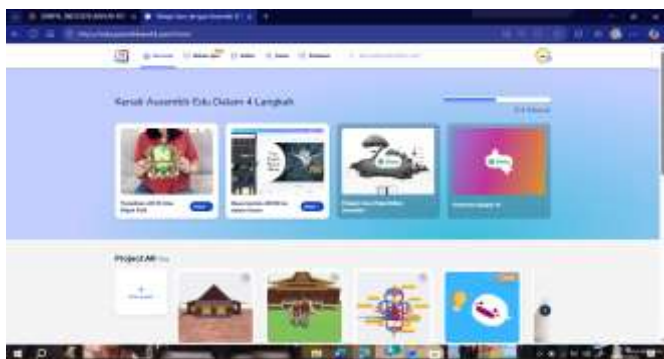


Figure 6. Work page display

The page above shows the work page located on the Assemblr Edu website. This page allows users to access several tools available on Assemblr Edu. It is used to create designs on worksheets.



Figure 7. Project display

On this page, there has been progress from what was initially a blank sheet, which is now filled with designs created by the researcher.

The researcher created the design so that students could understand the material more thoroughly. The researcher designed the media to be as interesting as possible so that students would not get bored during learning. This display contains 3D images so that students can see the whole picture and understand the form and usage.

In the display above, the researcher developed a learning medium using a new method where the researcher combined commonly used teaching materials with 3D technology. Therefore, the researcher created a design in accordance with the needs, which can be seen in the diagram below:

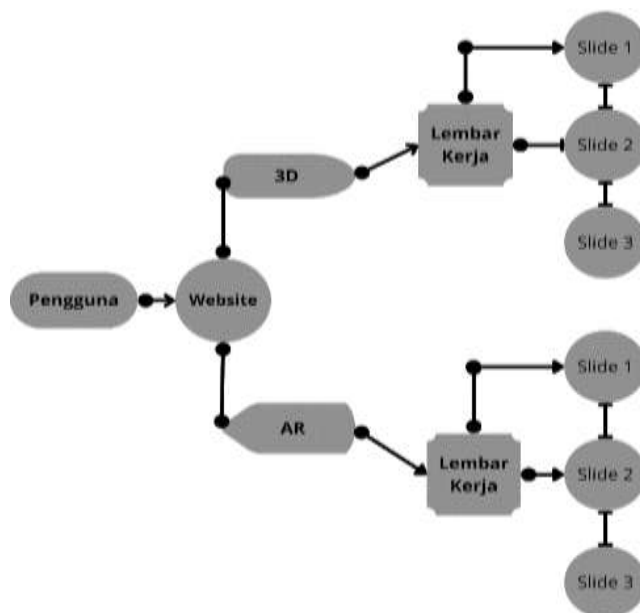


Figure 8. Media design diagram

After expert media validators and expert material validators gave their recommendations, this research was tested on fifth-grade students. The trial was conducted by researchers accompanied by fifth-grade teachers, presenting teaching materials and interactive teaching media supported by the Assemblr Edu website. interactive teaching materials and media supported by the Assemblr Edu website.

In this research and teaching material trial, question validation tests were conducted in higher grades to determine whether the questions were suitable for fifth-grade students by calculating the number of questions that were suitable for use in fifth grade.

Then, if the questions are suitable, the test will be continued for fifth-grade students at Podorejo 2 Elementary School, where this test will produce

assessments, comments, input, and suggestions for the media that the researcher has developed

The research also obtained approval from two expert validators, namely media validators and material validators. The media validator for this study is Mr.

Abtadi Tris Hamdani, S.Pd., M.Pd. The second validator is the material validator, Ms. Fitria Dwi Prasetyaningtyas, S.Pd, M.Pd., a lecturer in the elementary school teacher education study program.

**Table 1.** Media and Material Validation Test Results

Name	Validator	Average	Percentage
Abtadi Tris Hamdani, S.Pd., M.Pd.	Validator	90	90
Fitria Dwi Prasetyaningtyas, S.Pd, M.Pd.	Material	95	95

From the percentage table above, it can be seen that the media and materials are suitable for use without revision, based on the results issued by media and materials experts with an average score of 90 and a percentage of 100%, which means they are categorized as good for use with revision. Then from the material experts, a score of 95 with a percentage of 100% was obtained, categorized as very good for use without revision. Thus, the conclusion from the expert validators is that this media is suitable for use by students with minor revisions.

*Implementation*

In the stage before implementation, namely the validation stage, after the validation stage, now is the stage of testing the teaching materials and media that the researcher has created. The testing of these teaching materials and media was carried out in the classroom. At SD Podorejo 02, the purpose of this test was to determine how students responded after using the teaching materials and media created by the researcher, as well as to test whether the media created by the researcher was suitable for students after being tested by teachers and students. Then, the students were given the test sheets again to test whether they had understood the material or not.

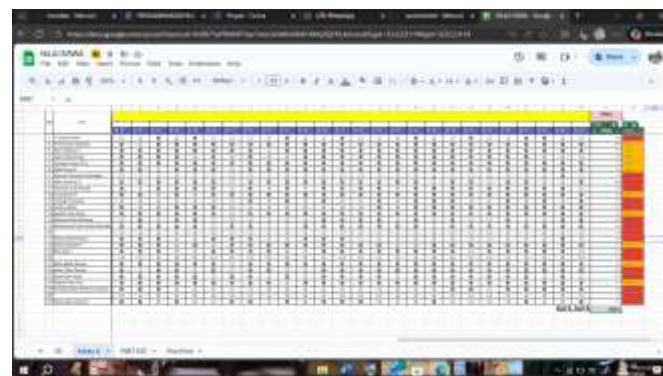
*Evaluation*

At this stage, students assessed the learning media. Thus, quantitative data will be used to analyze whether the teaching materials and learning media created by the researcher are suitable or not.

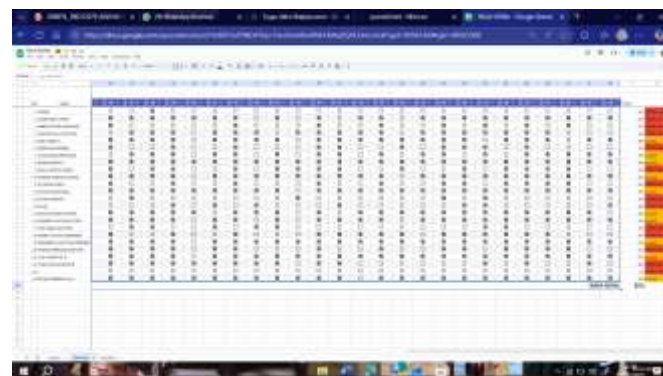
After the students tried the teaching media personally using their respective mobile phones, they were then given questions to answer. The purpose of giving these questions was to test whether the students understood the material or not. Based on the results of the questions and answers between the students and the researcher, it was found that the students were happy with the learning media.

At Podorejo 02 Public Elementary School, Ngaliyan District, Semarang City. Students and parents were given several questionnaires. For parents, there was a questionnaire about their children's use of mobile

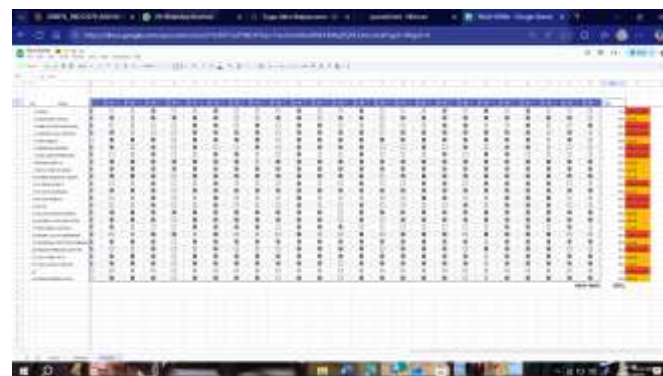
phones at home, while for children, there was a questionnaire to analyze research data. The following are the results from the students of Podorejo 02 Public Elementary School:



**Figure 9.** Results of the test validity



**Figure 10.** Results of the pre-test



**Figure 11.** Results of the post-test

### *Research Findings Achieved*

The results of the research conducted at Podorejo 02 Public Elementary School and the responses from the students, who were very happy with the learning media developed by the researcher, show that the teaching materials and media developed by the researcher can be used and meet the requirements for IPAS learning media for grade 5 at Podorejo 02 Public Elementary School. because in this study, in addition to improving students' understanding, this study can also improve students' thinking where they are able to develop new things that they have not previously obtained.

From the effectiveness of the learning media created by the researcher, the researcher has proven that the learning media developed using the ADDIE method showed evaluation results indicating that this learning media was able to attract students' attention and understanding. Using the ADDIE method, the learning objectives designed by the researcher have the researcher has evaluated the efficiency of the learning media development process that has been carried out, then the researcher has also analyzed the extent to which the efficiency of using the ADDIE method allows for the development of more structured and organized learning. The conclusion of the overall research can include recommendations for further improving the learning media developed by the researcher. This development can take the form of suggestions for improving the design, comments on the use of technology, or suggestions for future development to make it better.

The results are valid and practical in the development of teaching materials assisted by Assemblr Edu in the IPAS subject at Podorejo 02 Public Elementary School, which is based on Augmented Reality through several stages of development carried out by researchers and several validations validated by expert validators in their fields. thus, the teaching materials assisted by Assemblr Edu in the IPAS subject at Podorejo 02 Public Elementary School are valid and suitable for use at Podorejo 02 Public Elementary School.

## **Conclusion**

This study aims to determine how Augmented Reality Teaching Materials can improve students' understanding and skills, given that students initially had difficulty understanding the material because the teaching method used was still the old method, commonly known as the lecture method. Here, the researcher presents a new learning concept, namely using a learning method in which students are actively involved in learning. The researcher uses the ADDIE research method, in which this research begins with at this stage, initial observations were conducted at SDN

Podorejo 02, with m pages and classrooms, and a direct meeting with the principal. Next, communication with the fifth-grade homeroom teacher about IPAS subjects. The researcher analyzed how fifth-grade, After conducting an analysis and identifying the problems from the school's analysis, the researcher attempted to design and create a highly interactive learning medium that follows technological developments to replace the old learning method, which only used thick printed books and lectures, Next, for this stage, the development product is ready to be created according to the plan made by the researcher; learning media is prepared, and media is created. Media experts and material experts in their fields are also referred to as teachers, whose job is to guide and check whether the material from the media complies with existing regulations to ensure its validity. After conducting a series of tests through media experts and after going through the revision stage, the next step is to implement the media to students to see whether or not this learning media can improve student learning outcomes. After implementing the media created at Podorejo 02 Public Elementary School, the next step is to evaluate the results of the implementation which involves conducting a formative and summative evaluation to measure whether this media can improve student learning outcomes in Grade V IPAS lessons. And then this conclusion this Based on the results of the research and discussion of teaching materials assisted by Augmented Reality in IPAS lessons at Podorejo 02 Public Elementary School, the following conclusions can be drawn : Development of teaching materials assisted by Augmented Reality in IPAS lessons at Podorejo 02 Public Elementary School using the ADDIE method on the Assemblr Edu website, which shows 3D and AR technology that functions as a teaching medium that can display the shape of objects or images in 3D. Based on the responses from the students, a score of 69% was obtained, indicating an increase from the initial stage where the students did not understand the material to the stage where they became familiar with it. Therefore, this medium is categorized as suitable for use.

## **Acknowledgments**

Thank you to all parties who have helped in this research so that this article can be published.

## **Author Contributions**

Firstyansa Heriyanto contributed to the reseach, product development, data analysis, and writing of the article, Eka Titi Andaryani as a supervisor in reseach activies until writig the article.

## **Funding**

This research is an independent research whose operational cost are borne by the research.

**Conflicts of Interest**

No conflict interest.

**References**

- Bagaskara, F. R., Pahrudin, A., Jatmiko, A., & Koderi. (2024). Evaluasi Kurikulum Dan Pembelajaran PAI Dalam Meningkatkan Kualitas Pendidikan Dasar Di Era Digital. *Jurnal Ilmiah Pendidikan Dasar*, 5(2), 341-351. Retrieved from <https://jurnal.iaihpancor.ac.id/index.php/badaa/article/view/1748>
- Boboc, R. G., Băutu, E., Gîrbacia, F., Popovici, N., & Popovici, D.-M. (2022). Augmented Reality in Cultural Heritage: An Overview of the Last Decade of Applications. *Applied Sciences*, 12(19), 9859. <https://doi.org/10.3390/app12199859>
- Dewi, K., & Sahrina, A. (2021). Urgensi augmented reality sebagai media inovasi pembelajaran dalam melestarikan kebudayaan. *Jurnal Integrasi Dan Harmoni Inovatif Ilmu-Ilmu Sosial (JIHI3S)*, 1(10), 1077-1089. <https://doi.org/10.17977/um063v1i10p1077-1089>
- Doyan, A., Gunawan, Susilawati, Khasanah, B. U., & Mulyadi, L. (2020). The effectiveness of quantum phenomenon learning media with think pair share model implementation on understanding concept of students. *Journal of Physics: Conference Series*, 1521(2). <https://doi.org/10.1088/1742-6596/1521/2/022037>
- Doyan, A., Jufri, A. W., Susilawati, Hardiyansyah, A., Auliya, K., Hakim, S., & Mulyadi, L. (2020). Development of Learning Media of Microscope Portable Auto Design to Increase Student's Problem-Solving Ability in Light and Optical Tools Topic. *4th Asian Education Symposium (AES 2019)*, 300-302. <https://doi.org/10.2991/assehr.k.200513.068>
- Hidayah, N., Andaryani, E. T., Utomo, U., & ... (2024). Implementasi Pembelajaran Mengenal Macam-Macam Alat Musik Dengan Model Project Based Learning Berbantuan Media Flipbook. *Didaktik: Jurnal Ilmiah PGSD STKIP Subang*, 10(4), 331-344. Retrieved from <http://journal.stkipsubang.ac.id/index.php/didaktik/article/view/4575>
- Irmade, O., Widjanarko, P., & Andaryani, E. T. (2022). Augmented Reality as Early Childhood Learning Media: Environment Theme. *Edukasi*, 16(1), 12-19. <https://doi.org/10.15294/edukasi.v16i1.36655>
- Khasanah, B. U., Doyan, A., Gunawan, G., Susilawati, S., Kartini, K., Hakim, S., & Mulyadi, L. (2019). Analysis Validation of Learning Media Quantum Phenomenon. *Jurnal Penelitian Pendidikan IPA*, 5(2), 189-193. <https://doi.org/10.29303/jppipa.v5i2.265>
- Laksana, S. D. (2021). Pentingnya Pendidikan Karakter Dalam Menghadapi Teknologi Pendidikan Abad 21. *Jurnal Teknologi Pembelajaran*, 1(01), 14-22. <https://doi.org/10.25217/jtep.v1i01.1289>
- Lyanda, D., Halim, R. M. N., & Syakti, F. (2023). Media Pembelajaran Animasi 3D Sistem Tata Surya Menggunakan Metode ADDIE. *Jurnal Teknologi Dan Sistem Informasi Bisnis*, 5(4), 528-533. <https://doi.org/10.47233/jteksis.v5i4.1037>
- Majir, A. (2020). *Paradigma baru manajemen pendidikan abad 21*. Deepublish.
- Maulida, D. K., & Andaryani, E. T. (2025). Pengembangan Media Papan Pintar pada Materi Pengamalan Nilai-Nilai Pancasila untuk Meningkatkan Hasil Belajar Siswa. *JIP - Jurnal Ilmiah Ilmu Pendidikan*, 8(9), 10800-10808. <https://doi.org/10.54371/jiip.v8i9.9282>
- Mulyadi, L., Doyan, A., Susilawati, Hamidi, Hakim, S., & Munandar, H. (2023). Training on Using PhET Virtual Media on Newton's Law of Gravity for Class X Students at Islamic Senior High School of Syaikh Abdurrahman Kotaraja, East Lombok. *BPI Journal of Community Service*, 1(1), 15-18. Retrieved from <https://journals.balaipublikasi.id/index.php/jcss/article/view/68>
- Munandar, H., Doyan, A., Susilawati, S., Hakim, S., Mulyadi, L., & Hamidi, H. (2024). Increasing Motivation to Study Physics Using PhET Media on Mechanical Energy Material. *MANDALIKA: Journal of Social Science*, 2(1), 1-5. <https://doi.org/10.56566/mandalika.v2i1.70>
- Oktaviara, R. A., & Pahlevi, T. (2019). Pengembangan E-modul Berbantuan Kvisoft Flipbook Maker Berbasis Pendekatan Saintifik pada Materi Menerapkan Pengoperasian Aplikasi Pengolah Kata Kelas X OTKP 3 SMKN 2 Blitar. *Jurnal Pendidikan Administrasi Perkantoran*, 07(03), 60-65. Retrieved from <https://ejournal.unesa.ac.id/index.php/JPAPUN ESA/article/view/29542>
- Paulauskas, L., Paulauskas, A., Blažauskas, T., Damaševičius, R., & Maskeliūnas, R. (2023). Reconstruction of Industrial and Historical Heritage for Cultural Enrichment Using Virtual and Augmented Reality. *Technologies*, 11(2), 36. <https://doi.org/10.3390/technologies11020036>
- Pauziah, D., & Laksanawati, W. D. (2023). Pengembangan Media Pembelajaran Fisika Berbasis Augmented Reality Pada Materi Struktur Kristal. *Jurnal Penelitian Pembelajaran Fisika*, 14(2), 179-188. <https://doi.org/10.26877/jp2f.v14i2.15763>
- Rizqi, F., Supriyanto, T., Astuti, T., & ... (2023). Pengaruh

Penerapan Kurikulum Merdeka Dan Motivasi Belajar Terhadap Hasil Belajar Ips Siswa Kelas Iv Sd Di Gugus Pangeran .... *Journal of Elementary Education*, 5(2), 111-121. Retrieved from <https://journal.unnes.ac.id/sju/jee/article/view/77625>

- Sari, I. P., Batubara, I. H., Hazidar, A. H., & Basri, M. (2022). Pengenalan Bangun Ruang Menggunakan Augmented Reality sebagai Media Pembelajaran. *Hello World Jurnal Ilmu Komputer*, 1(4), 209-215. <https://doi.org/10.56211/helloworld.v1i4.142>
- Xu, N., Li, Y., Wei, X., Xie, L., Yu, L., & Liang, H.-N. (2024). CubeMuseum AR: A Tangible Augmented Reality Interface for Cultural Heritage Learning and Museum Gifting. *International Journal of Human-Computer Interaction*, 40(6), 1409-1437. <https://doi.org/10.1080/10447318.2023.2171350>