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Development of E-Learning Materials Assisted by Augmented Reality in the Subject of Social Sciences, Cultural Diversity Material

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Abstract: This study aims to develop, test the feasibility, effectiveness, and practicality of augmented reality (AR)-based e-learning materials in improving student learning outcomes. This study is a development research (R&D) using the Borg and Gall model involving 42 fifth grade students of Podorejo 02 Elementary School in the 2024/2025 academic year. Data collection was carried out through test techniques (pretest - posttest) and nontest. The results of the validation of material, language, and media experts showed that the media was very feasible to use. Positive responses from teachers and students to the practicality of the media, with a high level of satisfaction. The effectiveness of the media was proven by the t-test which showed significant results (0.000 <0.05) and an increase in learning outcomes (N-gain) in the "moderate" category. The results of the study indicate that e-teaching materials assisted by AR meet the criteria of being feasible, practical, and effective in improving learning outcomes in science learning for grade V at SD Negeri Podorejo 02.

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

Introduction

Education is the foundation of national progress (Rahmatsyah & Dwiningsih, 2021). As mandated in Permendikbudristek Number 22 of 2023, adequate facilities and infrastructure are very important to support effective learning. The facilities used include learning materials, learning tools and equipment. With conducive facilities and atmosphere, students can learn better. Learning is a way to understand the knowledge taught by teachers or experts in their fields (Maritsa et al., 2021). In this process, each component complements each other to create an optimal learning environment and produce graduates who are ready to face the future. This is in line with Permendikbudriset No. 16 of 2022 concerning Process Standards, emphasizing the importance of learning that is tailored to student needs and the use of technology to improve the quality of education. In practice, ideal learning is still far from reality. Teachers and students often face various obstacles, such as lack of learning resources and difficulties in adopting new technologies. The development of digital technology has had a significant impact on various fields (Buck et al., 2023; Cai et al., 2021; S. Li et al., 2023; X. Li et al., 2022; Ye et al., 2021). Digital technology is very important in science learning today (Hidayat et al., 2023).

Technology plays a very significant role in the learning process (Abba et al., 2020; Herman et al., 2022). The rapid development of technology provides a great opportunity to develop and implement innovative learning media. This is in contrast to the main problem faced by education today, namely the low utilization of technology, especially smartphones, as a learning tool. Many students have access to smartphones but rarely use them to improve their understanding of subject

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matter, such as science and science. This shows a gap between the potential of technology and actual learning practices (Dewi & Handayani, 2021). Innovation in the development of teaching materials is the key to improving the quality of learning. Monotonous and less interesting teaching materials can reduce students' interest in learning, so efforts need to be made to create teaching materials that are more innovative and in accordance with students' needs. Analysis of data obtained from interviews, questionnaires, observations, grade lists, and documentation of class V of Podorejo 02 Elementary School showed similarities in learning problem patterns with previous research findings.

The results of the questionnaire filled out by 27 class V students showed that the science and science subjects were less popular. As many as 4 students (14.81%) like mathematics, 2 students (7.40%) like science, 15 students (55.55%) like physical education, 4 students (14.81%) like civics, and 2 students (7.40%) like other subjects. Especially on the material of cultural diversity in Indonesia, as many as 45% of students stated that they did not like this material for reasons that it was not interesting (33%), difficult to understand (30%), too much theory (33%), and other reasons (4%). Based on the questionnaire response data, it shows that students' interest in science, especially cultural diversity, is still low. Based on a preliminary study, it was found that the availability of teaching materials that are appropriate to the needs of students at Podorejo 02 Elementary School is still limited. Teachers tend to rely on governmentpublished textbooks, such as teacher books and student books. Although textbooks are equipped with illustrations, not all concepts can be visualized well. Teachers also sometimes use materials from YouTube without modifying them according to the needs of students. This is in contrast to the Wi-Fi network facility which is not optimally utilized. This indicates the need to develop teaching materials that are more relevant, contextual, and utilize technology to improve learning effectiveness.

The problem of using technology, especially smartphones, in learning is still often encountered. Based on the results of a questionnaire filled out by fifth grade students at Podorejo 2 Elementary School, 21 out of 25 students (84%) already have smartphones that can be used to access the internet. In addition, these students are also proficient in operating smartphones. However, students do not make good use of their smartphones. Overall, students more often use smartphones to play games, play social media and watch YouTube. Students use smartphones to study when they have assignments. This means that 21 out of 22 students (95%) are already proficient in using smartphones but are less than optimal in everyday use. This is supported by the haunted results that have been filled in by parents. 12 out of 15 (80%) parents of students allow students to bring smartphones to school under teacher supervision. However, the data also shows that so far the use of smartphones among students is still limited to communication and entertainment purposes. Problems with the learning outcomes of class V students at Podorejo 02 Elementary School were also found. From the document data on the learning outcomes of class V students in the 2023/2024 academic year at Podorejo 02 Elementary School, it can be seen that the learning outcomes of science, especially in cultural diversity in Indonesia, are guite low. Of the 25 students, there are 22 students (88%) who have not met the KKTP, and 3 students (12%) who have met the KKTP, with the KKTP used being 66. This condition shows that learning is still not effective in helping most students achieve the expected competencies. Based on these various problems, creative efforts are needed to improve student achievement.

One solution is to develop digital teaching materials that can be combined with various technologies. Digital teaching materials are electronicbased learning materials presented in a more attractive format (Karim et al., 2020). The subject of science is very suitable for developing digital teaching materials because of the many abstract concepts that are difficult for students to understand. Digital teaching materials or also known as e-teaching materials, such as electronic books (e-books) are designed to provide flexibility for students to access learning materials anytime and anywhere using devices such as smartphones or laptops. Digital teaching materials utilize technology to combine various multimedia elements such as images, sound, and video into one attractive unit. The main advantage of this e-teaching material is its ability to present material in a more attractive way allowing for a variety of learning activities (Putra et al., 2023) and providing a richer learning experience through visualization and interaction. Another advantage of e-teaching materials is its practical and flexible nature, can be accessed anytime and anywhere, according to the needs of students in the digital era (Mu'afiqoh & Wachidah, 2024). The technology-based science learning approach, with an emphasis on visualization, has shown better results than conventional methods in increasing students' interest in learning and understanding. In line with this, one of the strategic steps in developing digital teaching materials is to integrate it with Augmented Reality technology.

Augmented Reality is a technology that combines three-dimensional virtual elements into a real environment in real time, which can be accessed through devices such as smartphones (Hernanda & Aji, 2024). The integration of these virtual objects into the real

world allows for clearer and more meaningful visualizations, especially for abstract concepts that are difficult to imagine. The application of Augmented Reality technology in science subjects, especially in the material on cultural diversity in Indonesia, offers a more innovative and effective learning approach for elementary school students. Through Augmented Reality (AR) technology, elementary school students can directly interact with three-dimensional models of cultural diversity in Indonesia, thereby increasing conceptual understanding (Amirahma & Setyasto, 2024). E-learning materials equipped with Augmented Reality technology facilitate students' understanding of abstract concepts in Natural Sciences (IPA) in greater depth (Hafizhah & Setyasto, 2024). In addition to encouraging interest in learning, Augmented Reality has also proven effective in improving students' learning outcomes. This learning media not only provides a fun learning experience, but also stimulates students' motivation to actively participate and work together in the learning process.

In addition, augmented Reality makes a significant contribution to the development of critical thinking skills and students' creativity (Dendodi et al., 2024; Kaharuddin et al., 2023). E-learning materials assisted by Augmented Reality are practical to use and make it easy for students to access learning materials. The novelty of this study compared to previous studies lies in the use of non-print media assisted by AR technology. This elearning material is intended for grade V Elementary School with the material Cultural Diversity in Indonesia. The developed e-learning materials allow students to scan markers in the form of QR codes connected to ARbased visualizations. The AR-based e-learning materials developed in this study are designed to provide learning flexibility for students. With the QR code scanning feature, students can access learning materials anytime and anywhere using their digital devices. This makes it easier for students to learn independently and more flexibly. Through AR-based e-learning materials, students can scan QR codes related to 3D images in elearning materials to obtain AR visualizations. For example, the diversity of traditional clothing that is usually only in 2D images and descriptions in student books, in this e-learning material is visualized with Augmented Reality in a more concrete 3D form with the addition of traditional dance movement animations related to everyday life. This approach not only makes learning more interesting and interactive, but also provides a deeper and more comprehensive learning experience.

Based on the existing problems, this study focuses on the development of e-teaching materials assisted by augmented reality to help fifth grade students understand science material more easily at SD Negeri Podorejo 2. The main objective of this study is to test the feasibility, practicality and effectiveness of the developed products in improving student learning outcomes.

Method

This study uses the research & development (R&D) method to produce augmented reality-assisted elearning materials on cultural diversity in Indonesia. Research and Development (R&D) is a structured method for creating new innovations (Andriani & Ramadani, 2022). Research & development (R&D) research aims to develop certain learning products and test their effectiveness (Mcgill & Bax, 2005). In accordance with the characteristics of R&D, each stage of this research is interrelated. Starting from identifying problems in cultural learning, then designing solutions in the form of AR e-Learning Materials, then testing them to see how effective they are. The test results will provide valuable input for improvements in the next stage. This study adopts the Borg and Gall development model which consists of 10 steps: identifying potential and problems, data collection, product design, design validation, design revision, product trial, product revision, usage trial, product revision, and mass production. However, due to time and cost constraints, this study only covers 8 initial stages. This process can be seen visually in Figure 1.



Figure 1. Adapted from the Borg and Gall Model

The initial stage of this study focused on understanding the problems in learning science for grade V. We conducted direct observations, interviews with various parties, and analyzed student learning outcomes. In addition, we also collected data from teachers and students through questionnaires to find out their needs. The data was then used as a basis for designing learning products that were in accordance with the learning objectives set in the curriculum. The design of this learning product was then assessed by experts in learning materials and media. The experts provided assessments using a Likert scale to assess aspects of language, material content, and media design. The next stage was to improve the design of the teaching materials based on suggestions from the experts. The improved teaching materials were then tested on a small scale on 15 grade V students of Podorejo 02 Elementary School in the 2023/2024 academic year who had different abilities using the purposive sampling method based on the different levels of cognitive abilities of students. This trial used the problem-based learning (PBL) method by utilizing augmented reality (AR) technology. After the learning process, teachers and students were asked to give their opinions about the teaching materials.

The results of their opinions were used to revise the teaching materials. In the final stage, the revised teaching materials were tested on a large scale on 27 students of Elementary School V Podorejo 02 in the 2024/2025 academic year to determine the effectiveness of the products that had been developed based on the Learning Outcomes (CP) and Learning Objectives (TP) to be achieved. This study uses a combined approach between qualitative and quantitative data. Qualitative data were obtained through direct observation activities, interviews with teachers, and filling out questionnaires by students. Quantitative data were obtained from student scores, both before and after participating in learning. The research design used was a one-group pretest-posttest which allowed researchers to compare student learning outcomes before and after being given treatment. In this case, what is considered is changes in student learning outcomes so that they can be identified more accurately. The data collection methods in this study were very diverse. Data collection in this study was carried out through test and non-test techniques. The test technique used was a multiple-choice test of 35 questions that were the same for the pretest and posttest. These questions are designed to measure students' understanding of the material taught before and after the implementation of the developed learning media.

Table 1. Recapitulation of Question Item AnalysisResults.

| Analysis Criteria | Analysis Results |
|----------------------|---------------------------------------|
| Question Validity | All 35 questions are valid with |
| | correlation coefficient values > 0.51 |
| Question Reliability | Cronbach's Alpha Coefficient = 0.96 |
| Difficulty Level | 20 questions: Easy Category |
| | 14 questions: Medium Category |

While non-test techniques include observation, interviews, questionnaires, observations, value lists, and documentation. The assessment of e-teaching materials is carried out through several stages. The first stage is validation by experts to ensure the feasibility of eteaching materials. The validation process is carried out by lecturers at Semarang State University according to competence. The second stage is an assessment of practicality based on teacher and student responses. The assessment of feasibility and practicality is carried out using a Likert scale of 1-4. The last stage is quantitative data analysis to measure the effectiveness of teaching materials in improving student learning outcomes. Quantitative data analysis is carried out using statistical tests such as normality tests using the Shapiro-Wilk method through SPSS software, Paired Samples Test (ttest) and N-Gain test to ensure that the results obtained have a high level of significance.

Result and Discussion

Potential and Problems

In the early stages of the study, learning problems were identified through observation, interviews, and analysis of student learning outcome data. Based on initial observations at SDN Podorejo 02, it was seen that most students did not like science lessons, especially the material on cultural diversity in Indonesia. One of the causes is the lack of innovation in learning methods. This is due to the lack of innovation in learning media. Teachers sometimes still rely on teacher and student books that are not in accordance with learning objectives. Teachers tend not to optimize the information technology resources available in schools such as Wi-Fi and smartphones, which are connected to a Wifi network in each class. However, teachers tend to still use learning videos from YouTube which are still less in accordance with the characteristics of students. In implementing learning, students tend to show a passive attitude, this is reflected in the dominant use of the lecture method by teachers and the low participation of students in asking or answering questions. In addition, in the learning outcomes of the Science subject on cultural diversity in Indonesia for grade V at SD Negeri Podorejo 02, it is known that out of 25 students, 3 students (12%) have met the learning objective achievement criteria (KKTP). Meanwhile, 22 students (88%) have not met the learning objective achievement criteria (KKTP) with a minimum completion score of 66.

Data Collection

The researcher collected initial data by distributing questionnaires to teachers and students. Based on the results of the initial study, the researcher found that the current learning methods are still ineffective. The learning materials used are too monotonous and uninteresting, especially for subjects that are difficult to visualize such as the diversity of Indonesian culture. Teachers have also not been optimal in utilizing technology, such as smartphones, which are already widely owned by students (84%). In fact, students are very interested in using smartphones in learning (100%). In addition, support for the use of smartphones in learning also comes from parents, where 80% of them agree to their use in schools on the condition that they are under the supervision of teachers. This shows that there is a great opportunity to improve the quality of learning by developing interactive digital teaching materials. These digital teaching materials are expected to overcome the shortcomings of conventional teaching materials, such as lack of variation, difficult to carry, and less interesting. In addition, digital teaching materials can also utilize the potential of smartphones owned by students to provide a more exciting and enjoyable learning experience.

Product Design

This AR-assisted e-learning material was developed with reference to the learning outcomes (CP) and learning objectives (TP) that have been set. The design is adjusted to the characteristics of elementary school students, combining interesting visual elements such as images, animations, and 3D models. The manufacturing process involves several stages, starting from material planning to design development using the Canva and Assemblr Edu applications. The final stage is the integration between digital learning materials with augmented reality (AR) features through barcode codes. The final product of this learning media is a digital book that can be accessed online, and can be scanned using the Assemblr Edu application or website, Google Lens, or the default scanner application on a smartphone. The parts of this augmented reality-assisted e-learning material consist of the following components:



Figure 2. Front cover



instructions





Figure 8. Augmented reality of traditional Indonesian clothing



Figure 9. Augmented reality traditional customary house

Jurnal Penelitian Pendidikan IPA (JPPIPA)





Figure 10. LKPD

Figure 11. Back cover

The product design stages include material preparation; making 3D images using Assemblr Edu; and making teaching materials and applying augmented reality barcodes to teaching materials.

Validation of Augmented Reality-Assisted Teaching Material Product Design

Validation of learning products is carried out by experts to obtain input regarding the feasibility of the language, content, and media used. The assessment is carried out using a predetermined Likert scale. The results of the assessment are then analyzed to determine the level of product suitability with the established criteria. Product feasibility criteria are divided into five categories, namely very feasible, feasible, quite feasible, less feasible, and very unfeasible. A recapitulation of the assessment results by each validator is presented in Table 2.

Table 2. Results of Expert Validator Assessments of

 Augmented Reality-Assisted E-Teaching Materials

| Indicator | Language | Material | Media |
|------------------|---------------|---------------|---------------|
| | Validator | Validator | Validator |
| Total Score | 48 | 69 | 70 |
| Maximum Score | 52 | 76 | 80 |
| Percentage | 92.30% | 90.78% | 87.50% |
| Criteria | Very Worth It | Very Worth It | Very Worth It |

The validation data analysis presented in Table 2 indicates that the learning product has met the established eligibility standards. Based on expert assessments, both in terms of content, language, and media, this product is considered very feasible to use. Thus, the product is ready to enter the trial stage.

Design Revision

The next stage is the revision of the learning product design based on input from expert validators. revised product. Some of the changes made include the addition of local cultural examples, grammar improvements according to the General Guidelines for Indonesian Spelling (PUEBI), and improvements to the display design, such as color changes and the addition of chapter structures.

| Lines Dearth Logic County be and it is provide the Anapole | - |
|--|---|
| Consoli-legana | An of halonging |
| 4. Anno and an anno anno anno anno anno anno | Provide the second s |

Figure 12. There is no local content in the surrounding environment



Figure 14. Use of introductory words



Figure 16. There are no chapters or sub-chapters yet



Figure 13. Local loads in the surrounding environment



Figure 15. Substitution for foreword



Figure 17. There are chapters and subchapters



Figure 18. The paragraph writing layout has not been



Figure 20. Colors that almost blend together make the writing difficult to read

Practicality of Augmented Reality-Assisted Teaching Materials (Product Trial)

The next stage is the small-scale product trial stage using 15 fifth-grade students of Podorejo 02 Elementary School in the 2023/2024 academic year using the purposive sampling method based on their cognitive ability levels. The learning method used is Problem Based Learning (PBL) by utilizing augmented realityassisted e-teaching materials. Next, after the small-scale trial, the e-teaching materials were tested on a large scale using 27 fifth-grade students of Podorejo 02 Elementary School in the 2024/2025 academic year. Response data collection will be carried out through a questionnaire consisting of 24 questions for teachers and 14 questions for students. This questionnaire uses a Likert scale of 1-4 to measure the level of suitability of the teaching materials with learning objectives.

Table 3. Results of the Teacher and Student Response Questionnaire to the Use of Augmented Reality-Assisted E-Teaching Materials in Small-Scale Trials

| E reacting materials in omain searce mais | | | |
|---|----------------|----------------------|--|
| Respondent | Percentage (%) | Eligibility Criteria | |
| Teacher | 96.87 | Very Positive | |
| Students | 80.95 | Positive | |



Figure 19. The paragraph writing layout has been



Figure 21. The color has been changed so that the text can be read clearly

Data analysis in Table 3 shows that teachers gave a very positive assessment (96.87%) to AR-assisted elearning materials. Meanwhile, students gave a positive assessment (80.95%). These results indicate that both teachers and students agree that these e-learning materials can be used effectively in the learning process. Based on the average score on the Likert questionnaire, it can be concluded that these e-learning materials are very positive and practical to implement.

Table 4. Results of the Questionnaire Responses of Teachers and Students to the Use of E-learning Materials Assisted by Augmented Reality Large-Scale Trials

| 11001000000 | | ocure mano |
|-------------|----------------|----------------------|
| Respondent | Percentage (%) | Eligibility Criteria |
| Teacher | 95.83 | Very Positive |
| Students | 93.25 | Very Positive |

The data in Table 4 shows that both teachers and students gave scores above 81% for AR-assisted elearning materials. These results are very satisfying and indicate that these e-learning materials are considered very positive and practical for use in daily learning activities.

Effectiveness of Augmented Reality-Assisted E-Learning Materials

At this stage, a small-scale trial was conducted on grade V students of Podorejo 02 Elementary School in the 2023/2024 academic year with a total of 15 students using Augmented Reality-assisted e-learning materials in the Science subject on the subject of cultural diversity in Indonesia to determine the effectiveness of the products developed by researchers based on student learning outcomes. The research design used was a preexperimental design with a one-group pretest-posttest design model, namely there was a pretest before treatment was given and a posttest after treatment was given.

Table 5. Results of the Pretest and Posttest of Students

 in the Small-Scale Test

| Test Type | Average | Average Difference |
|-----------|---------|--------------------|
| Pretest | 45.33 | 01.00 |
| Posttest | 76.66 | 51.55 |

Quantitative data analysis in Table 5 shows a significant difference between student learning outcomes before and after being given treatment using AR-assisted e-learning materials. An average increase of 31.33 points indicates that the use of AR-assisted elearning materials is effective in improving students' understanding of the material on Indonesian cultural diversity. Furthermore, a large-scale trial of AR-assisted e-learning materials was conducted on 27 fifth grade students of Podorejo 02 Elementary School in the 2024/2025 academic year. This study aims to evaluate the effectiveness of the developed product in improving student learning outcomes on the material on Indonesian cultural diversity. The research design used was a pre-experimental design with a one-group pretestposttest design model to compare student learning outcomes before and after being given treatment.

Table 6. Results of the Pretest and Posttest of Students in the Large-Scale Test

| Test Type | Average | Average Difference |
|-----------|---------|--------------------|
| Pretest | 63.28 | 17.25 |
| Posttest | 80.63 | 17.55 |

Quantitative data analysis in Table 6 shows a significant difference between student learning outcomes before and after being given treatment using AR-assisted e-learning materials. An average increase of 17.35 points indicates that the use of AR e-learning materials is effective in improving students' understanding of the material on cultural diversity in Indonesia. Further data analysis used the Paired Samples Test (t-test) to compare student learning outcomes before and after using e-learning materials. Before that, the researcher conducted a normality test using the Shapiro-Wilk method through SPSS software to ensure that the data was normally distributed. This normality test uses significance values as a reference. If the significance value is greater than 0.05, then the data can be considered normally distributed. The results of this normality test are summarized in Table 7.

Table 7. Results of the Data Normality Test

| Normality test | | | | |
|----------------|------------|----|------|--|
| Shapiro-V | | | | |
| Pretest value | Statistics | Df | Sig. | |
| Posttest value | .93 | 27 | .083 | |
| Normality test | .95 | 27 | .214 | |

The results of the normality test in Table 7 show that the data are normally distributed. Therefore, further analysis uses paired sample test to test the research hypothesis. The decision-making criteria are if the significance value (two sides) is less than 0.05, then the null hypothesis is rejected and the alternative hypothesis is accepted, which means there is a significant difference between the pretest and posttest values. The results of the Paired Sample Test analysis are shown in Table 8.

Table 8. Paired Sample Test Results (T-Test)

| Paired Sample Test | | | | |
|---|--------|----|------|--|
| Pretest Score - T-statistic Degree of freedom Sig. (2-tat | | | | |
| Posttest Score | -6.167 | 26 | .000 | |

Based on the results of the paired t-test, a significance value of 0.000 was obtained, which is much smaller than the significance level of 0.05. This shows that there is a very statistically significant difference between the pretest and posttest scores. In addition, this is also reinforced by the results of the N-gain analysis which shows a significant increase in student learning outcomes after being given treatment using augmented reality.

| Table | 9. | N-Gain | Test | Resul | lts |
|-------|----|--------|------|-------|-----|
|-------|----|--------|------|-------|-----|

| Average Difference | N-Gain | Group | |
|--------------------|--------|-----------|--|
| 17.35 | 0.47 | Currently | |

The N-gain analysis in Table 9 shows that the average increase in student learning outcomes is 0.47, which is included in the "moderate" category. This indicates that the use of augmented reality-assisted elearning materials on the human digestive system material has had a positive impact on improving the learning outcomes of fifth-grade students at Podorejo 02 Elementary School. Based on the data analysis, it can be concluded that the augmented reality-assisted elearning materials developed have met the standards set in terms of feasibility, practicality, and effectiveness in improving the learning outcomes of fifth-grade students on the material on cultural diversity in Indonesia. This shows that the use of AR technology in learning can be a suitable alternative. This is supported by several supporting factors

First, the application of augmented reality (AR) technology in teaching materials has brought a breath of fresh air to the world of education. Various studies have shown that AR is very effective in increasing student learning motivation, especially in understanding complex science concepts (Prasetya et al., 2024). Interactive and immersive three-dimensional visualization allows students to interact directly with the learning materials (Chen, 2020) making the learning experience more interesting and meaningful (Cecotti et al., 2024). This not only stimulates students' interest in reading (Câmara Olim et al., 2024; Mellyzar et al., 2024) but also encourages them to think critically (Ding et al., 2024; Shin et al., 2023), and develop 21st century skills (Rais et al., 2024), which are very much needed in facing real-world challenges. With AR, students can learn while playing and explore abstract concepts in a more enjoyable way. Second, AR-based e-teaching materials are an innovation that can change the way teachers teach and students learn (Novit et al., 2023; Peikos & Sofianidis, 2024). With AR, teachers can create a more dynamic and interactive learning environment (Zhao et al., 2023), so that students do not get bored easily. In addition, AR also allows students to learn

independently outside the classroom (Ashari, 2023). The flexibility of using AR makes it a very practical learning medium (Garlinska et al., 2023; Rauschnabel et al., 2022).

AR-based e-learning materials can be accessed anytime and anywhere via devices such as smartphones or tablets, so that students can learn according to their own rhythm and learning style. Third, Based on the results of the study, AR-based e-learning materials have proven to be very practical to use in the learning process (Al-Ansi et al., 2023; Tuli et al., 2022; Yusa et al., 2023). This media is easy to operate and does not require complicated equipment. This makes AR easy to integrate into daily learning activities. In addition, AR also increases the overall effectiveness of learning. By using AR, students can more easily understand difficult concepts (O'Connor & Mahony, 2023; Radu et al., 2023), remember information longer, and achieve better learning outcomes. This study shows that AR e-learning materials can be an effective solution to improve the quality of science learning in grade V of elementary school. Guided by the results of previous studies, conditions, and problems in the field, researchers have succeeded in developing e-learning materials assisted by augmented reality for science learning in grade V elementary school students. Based on the results of the research and analysis that have been carried out, this augmented reality-assisted e-teaching material has proven to be feasible, practical, and effective for use in science learning for grade V elementary school students.

Conclusion

Based on the research results, augmented realitybased e-teaching materials on the material of Indonesian cultural diversity in class V of Podorejo 02 Elementary School have proven to be feasible, practical, and effective in improving student learning outcomes. These results are supported by very feasible expert assessments, positive responses from teachers and students, and significant improvements in learning outcomes. Thus, these e-teaching materials are recommended to improve student learning outcomes on the material of Indonesian cultural diversity.

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Author Contributions

F. H. K. N contributed to the research, product development, data analysis, and writing of the article. N. S., as a supervisor in research activities until writing the article.

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Conflicts of Interest

The author declares that he has no conflict of interest.

References

- Abba, S. I., Hadi, S. J., Sammen, S. S., Salih, S. Q., Abdulkadir, R. A., Pham, Q. B., & Yaseen, Z. M. (2020). Evolutionary computational intelligence algorithm coupled with self-tuning predictive model for water quality index determination. *Journal of Hydrology*, 587. https://doi.org/10.1016/j.jhydrol.2020.124974
- Al-Ansi, A. M., Jaboob, M., Garad, A., & Al-Ansi, A. (2023). Analyzing augmented reality (AR) and virtual reality (VR) recent development in education. *Social Sciences and Humanities Open*, 8(1), 100532.

https://doi.org/10.1016/j.ssaho.2023.100532

- Amirahma, S., & Setyasto, N. (2024). Development of Augmented Reality-Assisted Teaching Materials in Science Subjects: Solar System Topic. Jurnal Penelitian Pendidikan IPA, 10(5), 2346–2355. https://doi.org/10.29303/jppipa.v10i5.7027
- Andriani, M. W., & Ramadani, A. (2022). The Effect of Using Android-Based Augmented Reality Media on Critical Thinking Skills of Elementary School Class Students. *JUPE : Jurnal of Mandala Education*, 7(2), 567-576.

https://doi.org/10.58258/jupe.v7i2.3849

- Ashari, D. (2023). Analisis Pemanfaatan Media Pembelajaran Augmented Reality (Ar) Untuk Meningkatkan Keterampilan Berpikir Kritis. *Khazanah Pendidikan*, 17(1), 176. https://doi.org/10.30595/jkp.v17i1.16040
- Buck, C., Clarke, J., Torres de Oliveira, R., Desouza, K. C., & Maroufkhani, P. (2023). Digital transformation in asset-intensive organisations: The light and the dark side. *Journal of Innovation & Knowledge*, 8(2), 100335. https://doi.org/10.1016/J.JIK.2023.100335

- Cai, L., Xing, C., & Deng, Y. (2021). Research on digital urban architecture design based on cloud computing data center. *Environmental Technology & Innovation*, 22, 101543. https://doi.org/10.1016/J.ETI.2021.101543
- Câmara Olim, S., Nisi, V., & Romão, T. (2024). Augmented reality interactive experiences for multi-level chemistry understanding. *International Journal of Child-Computer Interaction*, 42(August). https://doi.org/10.1016/j.ijcci.2024.100681
- Cecotti, H., Huisinga, L., & Peláez, L. G. (2024). Fully immersive learning with virtual reality for assessing students in art history. *Virtual Reality*, *28*(1), 1–15. https://doi.org/10.1007/s10055-023-00920-x
- Chen, C. H. (2020). Impacts of augmented reality and a digital game on students' science learning with reflection prompts in multimedia learning. *Educational Technology Research and Development*, 68(6), 3057–3076. https://doi.org/10.1007/s11423-020-09834-w
- Dendodi, Simarona, N., Elpin, A., Bahari, Y., & Warneri. (2024). Analisis Penerapan Augmented Realitydalam Meningkatkan Efektifitas Pembelajaran Sains di Era Digital. *ALACRITY: Journal of Education*, 4(3), 293–304. https://doi.org/10.52121/alacrity.v4i3.456
- Dewi, F. F., & Handayani, S. L. (2021). Pengembangan Media Pembelajaran Video Animasi En-Alter Sources Berbasis Aplikasi Powtoon Materi Sumber Energi Alternatif Sekolah Dasar. *Jurnal Basicedu*, 5(4), 2530–2540. https://doi.org/10.31004/basicedu.v5i4.1229
- Ding, Z., Miao, J., Yang, Y., & Zhu, W. (2024). Impact of 3D learning resources on learning resilience: mediating roles of positive emotion and cognitive load. *Humanities and Social Sciences Communications*, 11(1), 1–11. https://doi.org/10.1057/s41599-024-03544-x
- Garlinska, M., Osial, M., Proniewska, K., & Pregowska, A. (2023). The Influence of Emerging Technologies on Distance Education. *Electronics (Switzerland)*, 12(7).

https://doi.org/10.3390/electronics12071550

- Hafizhah, F. J., & Setyasto, N. (2024). Augmented Reality-Assisted Scrapbook Media Development in Natural and Social Science Learning. *Jurnal Penelitian Pendidikan IPA*, 10(7), 4149–4157. https://doi.org/10.29303/jppipa.v10i7.7258
- Herman, Shara, A. M., Silalahi, T. F., Sherly, & Julyanthry. (2022). Teachers' Attitude towards Minimum Competency Assessment at Sultan Agung Senior High School in Pematangsiantar, Indonesia. *Journal of Curriculum and Teaching*, 11(1),

1-14. https://doi.org/10.5430/jct.v11n2p1

- Hernanda, A., & Aji, A. S. (2024). Pemanfaatan Aplikasi Augmented Reality Untuk Pembelajaran Organ Tubuh Manusia Di Sekolah Dasar. *Jurnal Teknologi Dan Sistem Informasi Bisnis*, 6(1), 245–251. https://doi.org/10.47233/jteksis.v6i1.1166
- Hidayat, M. L., Prayitno, H. J., Anif, S., Meccawy, M., & Khanzada, T. J. S. (2023). Science Learning in Answering Digital Competency Needs of Pre-Service Math and Science Teachers in the Stem Context. Jurnal Pendidikan IPA Indonesia, 12(3), 410– 422. https://doi.org/10.15294/jpii.v12i3.43960
- Kaharuddin, K., Pernando, Y., Marfuah, M., & KH, M. (2023). Aplikasi Augmented Reality (AR) Sebagai Media Pembelajaran Sistem Rangka Manusia. *Journal of Information System Research (JOSH)*, 4(4), 1168–1175.

https://doi.org/10.47065/josh.v4i4.3685

- Karim, A., Savitri, D., & Hasbullah. (2020). Pengembangan Media Pembelajaran Matematika Berbasis Android Di Kelas 4 Sekolah Dasar. Jurnal Lebesgue: Jurnal Ilmiah Pendidikan Matematika, Matematika dan Statistika, 1(2), 63–75. https://doi.org/10.46306/lb.v1i2.17
- Li, S., Gao, L., Han, C., Gupta, B., Alhalabi, W., & Almakdi, S. (2023). Exploring the effect of digital transformation on Firms' innovation performance. *Journal of Innovation and Knowledge*, 8(1). https://doi.org/10.1016/j.jik.2023.100317
- Li, X., Wang, X., & Xu, W. (2022). The information technology revolution and structural labor change: Evidence from China. *Economic Modelling*, 115. https://doi.org/10.1016/j.econmod.2022.105956
- Maritsa, A., Hanifah Salsabila, U., Wafiq, M., Rahma Anindya, P., & Azhar Ma'shum, M. (2021).
 Pengaruh Teknologi Dalam Dunia Pendidikan. *Al-Mutharahah: Jurnal Penelitian dan Kajian Sosial Keagamaan, 18*(2), 91–100.
 https://doi.org/10.46781/al-mutharahah.v18i2.303
- Mcgill, T., & Bax, S. (2005). Learning IT: Where Do Lecturers Fit? International Journal of Information and Communication Technology Education (IJICTE), 1(3), 36–46. https://doi.org/10.4018/jicte.2005070103
- Mellyzar, M., Fatwa, I., Lukman, I. R., Dewi, U. M., & Pasaribu, A. I. (2024). VR Based Media for Three-Dimensional (3D) Visualization in Chemical Laboratory. Jurnal Penelitian Pendidikan IPA, 10(3), 1356–1361.
 - https://doi.org/10.29303/jppipa.v10i3.6180
- Mu'afiqoh, E. B., & Wachidah, K. (2024). Meningkatkan Kemampuan Membaca Siswa Kelas II dengan Augmented Reality. *Teaching, Learning and Development,* 2(2), 101–108.

https://doi.org/10.62672/telad.v2i2.35

- Novit, I. E., Virijai, F., & Asrizal. (2023). Light Wave Digital Learning Material with Augmented Reality and CTL Model to Improve Students' 4C Skill. *Journal of Education Research and Evaluation*, 7(3), 423–433. https://doi.org/10.23887/jere.v7i3.64595
- O'Connor, Y., & Mahony, C. (2023). Exploring the impact of augmented reality on student academic self-efficacy in higher education. *Computers in Human Behavior*, 149(September), 107963. https://doi.org/10.1016/j.chb.2023.107963
- Peikos, G., & Sofianidis, A. (2024). What Is the Future of Augmented Reality in Science Teaching and Learning? An Exploratory Study on Primary and Pre-School Teacher Students' Views. *Education Sciences*, 14(5). https://doi.org/10.3390/educsci14050480
- Prasetya, F., Fortuna, A., Samala, A. D., Rawas, S., Mystakidis, S., Syahril, Waskito, Primawati, Wulansari, R. E., & Kassymova, G. K. (2024). The impact of augmented reality learning experiences based on the motivational design model: A metaanalysis. *Social Sciences and Humanities Open*, 10(February), 100926.

https://doi.org/10.1016/j.ssaho.2024.100926

- Putra, A. P., Riyoko, E., & Fakhrudin, A. (2023). Pengembangan Bahan Ajar Digital Berbasis Hots Dengan Memanfaatkan Aplikasi Canva pada Mata Pelajaran IPA Kelas V SD. *Indonesian Research Journal On Education*, 3(2), 1074–1080. https://doi.org/10.31004/irje.v3i2.223
- Radu, I., Huang, X., Kestin, G., & Schneider, B. (2023).
 How augmented reality influences student learning and inquiry styles: A study of 1-1 physics remote AR tutoring. *Computers & Education: X Reality*, 2(February), 100011.
 https://doi.org/10.1016/j.cexr.2023.100011
- Rahmatsyah, S. W., & Dwiningsih, K. (2021). Development of Interactive E-Module on The Periodic System Materials as an Online Learning Media. Jurnal Penelitian Pendidikan IPA, 7(2), 255– 261. https://doi.org/10.29303/jppipa.v7i2.582
- Rais, R. D. A., Abdul Saman, & Herman. (2024). Pengembangan Media Interaktif Augmented Reality Berbasis Smartphone untuk Meningkatkan Kemampuan Literasi Anak Usia Dini. *Didaktika: Jurnal Kependidikan*, 13(2), 1595–1608. https://doi.org/10.58230/27454312.591
- Rauschnabel, P. A., Felix, R., Hinsch, C., Shahab, H., & Alt, F. (2022). What is XR? Towards a Framework for Augmented and Virtual Reality. *Computers in Human Behavior*, 133(May), 107289. https://doi.org/10.1016/j.chb.2022.107289

Shin, K. S., Cho, C., Ryu, J. H., & Jo, D. (2023). Exploring

the Perception of the Effect of Three-Dimensional Interaction Feedback Types on Immersive Virtual Reality Education. *Electronics (Switzerland)*, 12(21). https://doi.org/10.3390/electronics12214414

- Tuli, N., Singh, G., Mantri, A., & Sharma, S. (2022). Augmented reality learning environment to aid engineering students in performing practical laboratory experiments in electronics engineering. *Smart Learning Environments*, 9(1). https://doi.org/10.1186/s40561-022-00207-9
- Ye, Y., Wang, Q., & Wang, J. (2021). Green city air monitoring and architectural digital art design based on IoT embedded system. *Environmental Technology and Innovation*, 23. https://doi.org/10.1016/j.eti.2021.101717
- Yusa, I. W., Wulandari, A. Y. R., Tamam, B., Rosidi, I., Yasir, M., & Setiawan, A. Y. B. (2023). Development of Augmented Reality (AR) Learning Media to Increase Student Motivation and Learning Outcomes in Science. *Jurnal Inovasi Pendidikan IPA*, 9(2), 127–145. https://doi.org/10.21831/jipi.v9i2.52208
- Zhao, X., Ren, Y., & Cheah, K. S. L. (2023). Leading Virtual Reality (VR) and Augmented Reality (AR) in Education: Bibliometric and Content Analysis From the Web of Science (2018–2022). *SAGE Open*, *13*(3), 1–23.

https://doi.org/10.1177/21582440231190821