

Development of AR-based Diorama to Improve Critical Reasoning Dimension and Learning Outcomes of Fourth-Grade Elementary School Students

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Abstract

This research is motivated by teachers who have not used digital learning media, resulting in low critical reasoning and learning outcomes. The purpose of the research is to develop a design and test the feasibility and effectiveness of augmented reality-based diorama media to improve critical reasoning dimensions and learning outcomes of Pancasila education. This study uses the research and development method, specifically the ADDIE model, to create augmented reality-based diorama media for Pancasila education aimed at fourth-grade students at Public Elementary School (SDN) Kalibanteng Kidul 01 in Semarang City, Central Java. The study found that the media is highly suitable for education, with validation scores of 93.33% from media experts and 98.21% from material experts. The assessment of critical reasoning scored 95.24%. The t-test results supported the hypothesis, showing significant effectiveness with an N-gain score of 0.7901, classifying it as high. Overall, the study concludes that the augmented reality-based diorama media are effective in improving critical reasoning and learning outcomes related to Pancasila principles for these students in class IV, SDN Kalibanteng Kidul 01, Semarang City, Central Java.

Keywords: *augmented reality, critical reasoning dimension, diorama, learning outcomes.*

Abstrak

Penelitian ini dimotivasi oleh guru yang belum menggunakan media pembelajaran digital, sehingga mengakibatkan rendahnya penalaran kritis dan hasil belajar. Tujuan penelitian ini adalah untuk mengembangkan desain dan menguji kelayakan serta efektivitas media diorama berbasis augmented reality untuk meningkatkan dimensi penalaran kritis dan hasil belajar pendidikan Pancasila. Studi ini menggunakan

metode penelitian dan pengembangan, khususnya model ADDIE, untuk menciptakan media diorama berbasis augmented reality untuk pendidikan Pancasila yang ditujukan untuk siswa kelas empat di SDN Kalibanteng Kidul 01 di Kota Semarang, Jawa Tengah. Studi ini menemukan bahwa media tersebut sangat cocok untuk pendidikan, dengan skor validasi 93,33% dari pakar media dan 98,21% dari pakar materi. Penilaian penalaran kritis mendapat skor 95,24%. Hasil uji-t mendukung hipotesis, menunjukkan efektivitas yang signifikan dengan skor N-gain 0,7901, yang mengklasifikasikannya sebagai tinggi. Secara keseluruhan, penelitian ini menyimpulkan bahwa media diorama berbasis augmented reality efektif dalam meningkatkan penalaran kritis dan hasil belajar terkait prinsip-prinsip Pancasila bagi siswa kelas IV SDN Kalibanteng Kidul 01, Kota Semarang, Jawa Tengah.

Kata kunci: *augmented reality, dimensi bernalar kritis, diorama, hasil belajar.*

INTRODUCTION

Pancasila education is an important subject in the basic education curriculum in Indonesia. Through this subject, students are expected to understand and practice the values of Pancasila in everyday life (Fernanda et al., 2024). Teachers have not utilized digital-based learning media that are appropriate to students' characteristics. The only learning resources available are textbooks. This causes students to be less interested in what they are learning. For teaching and learning activities to be comprehended by students and to create a pleasant learning environment, learning media must be used. This will prevent students from being bored while learning in class and from becoming exclusively fixated on printed materials. The low critical thinking skills of students in PPKn subjects are caused by the lack of use of digital-based learning media (Anjela, Astuti, & Rohman, 2024). Since learning is now mostly conducted through ICT (binti Mohd et al., 2024), teachers as professionals need to be able to adjust to the times (Almoeather, 2020).

Learning now includes understanding scientific ideas and skills like practice, creativity, and adaptability. Emotions such as passion and hope, as well as character development, are also important in education (Rahim et al., 2023). The profile of Pancasila learners is an essential part of the independent curriculum set by the Ministry of Education and Culture (Kemendikbudristek, n.d.). Pancasila learners think critically about information and can assess and combine ideas using different learning methods and tools. Learning media is mainly divided into two types: traditional media and modern technology tools. (Fakhrudin et al., 2019). Prastowo (2019) states that "a diorama is a kind of three-dimensional mini perspective model to explain the actual view." One of the three-dimensional or concrete media that originates from the real world is diorama media. The materials required to create diorama media are readily available and may be utilized more than once (Budiani et al., 2023). Additionally, diorama media can provide students with a vivid picture of the subject matter, which can inspire them to have a positive learning experience. The conventional diorama can be improved by using AR. AR is an example of a learning tool that uses technology (Putra et al., 2024). Mahartika et al., (2023) stated that AR is a technology that combines real environments with computer data, like graphics, images, sound, or video. It creates immersive and authentic experiences (Ismayani, 2020) in (Al Ikhsan et al., 2022). This technology facilitates virtual features blending into the real world, making it hard to tell

what is physical and what is digital. It goes beyond traditional uses, merging digital and physical spaces effectively (Dieck, Jung, & Loureiro, 2021).

This virtual diorama combines real and virtual elements to offer an immersive experience (Harrington et al., 2019). A review of research on AR in education indicated that 28.5% of the applications used three-dimensional objects. Audio information was used in 10.7% of applications, and 7.19% of them connected to the World Wide Web (Harrington et al., 2019). Building on the findings of prior research conducted by Dellia et al. (2022); Rahmat et al. (2024); Rinaldi et al. (2024); Saputra, Lutfiah, & Rigeni (2024); Dewi, Triendhita et al. (2024); Marjaya, Antara, & Bayu (2024); and Elvina et al. (2024). Seven studies suggest that using AR helps improve student learning outcomes and is practical for education.

Research on the application of AR in education has been steadily expanding; however, there remains a paucity of studies specifically focused on the efficacy of AR-based dioramas in enhancing the critical reasoning abilities of elementary school students. The majority of existing research predominantly emphasizes aspects such as learning motivation, conceptual understanding, and overall learning outcomes, with the dimension of critical reasoning receiving insufficient attention. Furthermore, the implementation of AR in the form of dioramas at the elementary level is still notably limited. Conversely, educators continue to rely on traditional media, which does not effectively promote critical thinking among students. Insufficient critical reasoning may stem from various sources, including the students themselves, the instructional techniques employed by teachers, and various factors associated with the learning environment (Anggrella et al., 2024). Students who only focus on memorizing and understanding concepts in learning have low critical thinking skills (Van der Zanden et al., 2020). The application of conventional learning methods causes students to become passive and have low critical thinking skills (Rattanachaithada et al., 2025). Consequently, the development of AR-based dioramas as educational media presents an opportunity not only to enhance learning outcomes but also to cultivate critical reasoning skills, an area that remains underexplored in prior research.

Researchers created new media to explain the Pancasila precepts in society, which is different from past studies. Their innovation combines physical dioramas with AR. Unlike traditional dioramas that are fixed, this one can be rotated easily. When a specific marker on the diorama is scanned, a 3D image appears along with audio and animation for right or wrong quiz answers. This app works offline, making it usable without internet access. With growing technology use in classrooms, teachers are encouraged to effectively use this kind of media to meet learning goals (Hidayat & Nizar, 2021). Researchers are interested in developing augmented reality diorama media. The project aims to create and test an augmented reality diorama to see how effective it is in improving critical thinking and learning outcomes for fourth-grade students at Public Elementary School (SDN) Kalibanteng Kidul 01 in Semarang City, Central Java.

METHODS

The research and development (R&D) methodology formulated by Sugiyono (2019) serves as a systematic approach to creating frameworks, developing educational activities, and producing materials that adhere to essential quality standards. Within this context, the

development model utilized is the ADDIE model, as articulated by Branch (2009) and referenced in Hidayat & Nizar (2021b).

The ADDIE model encompasses five key phases: analysis, design, development, implementation, and evaluation. This particular model was selected due to its alignment with the objectives of the project, specifically aimed at designing and developing augmented reality-based diorama media. By employing the ADDIE development model in this study, a diorama integrated with AR will be created as a pedagogical resource for Pancasila education within elementary schools.

The first, an analysis was done to find out the challenges faced by educators through interviews with a fourth-grade teacher at Public Elementary School (SDN) Kalibanteng Kidul 01 in Semarang City; *second*, the design phase involves creating media manuscripts and a prototype of augmented reality-based diorama media; *third*, in the development stage, instructional media is produced, validated by experts, and revised; *fourth*, the implementation phase applies this media in the fourth-grade classroom, aiming to assess its practicality by evaluating student and teacher reactions and measuring effectiveness through N-gain tests comparing pretest and posttest scores; and *fifth*, the evaluation phase includes a thorough assessment of the media's results. The research employed a qualitative approach and a quantitative approach. Data analysis was conducted using both qualitative and quantitative methods.

The data collection techniques for this research included non-test methods derived from observations, interviews, and documentation, as well as assessments from material and media validators. Additionally, the data comprised results from a questionnaire targeting critical reasoning dimensions and a pretest and posttest. The study utilized various data analysis techniques, including normality tests, t-tests, and N-gain tests. The research procedure was conducted in three phases: the pre-research stage, the implementation stage, and the subsequent data processing and analysis stage.

The research took place at SDN Kalibanteng Kidul 01 in Semarang City, Central Java, during the even semester of the 2024/2025 academic year. The study focused on fourth-grade students. For the small-scale pilot test, six students were selected using purposive sampling techniques, while the large-scale trial involved 23 participants.

RESULTS AND DISCUSSION

This study is a research and development project based on the framework proposed by Sugiyono (2019). It employs the ADDIE development model, as outlined by Branch (2009) and referenced by Hidayat & Nizar (2021b). The description is as follows.

Analyze

This step strives to gather data on the use of educational media. A study was done with a fourth-grade teacher in Semarang City to find out the challenges teachers face. The interview showed that teachers mainly use basic materials like textbooks and limited technology, leading to students being uninterested and hesitant to ask questions. Questionnaires given to teachers and students highlighted the need for technology-based learning tools. It was found that teaching about the Pancasila precepts lacks technology integration, which is important for increasing student focus, improving critical thinking, and enhancing learning outcomes.

Design

The design process starts with gathering observations. Product design involves creating a media script for an augmented reality diorama based on a careful evaluation of educator and student needs. Researchers adjust the product to meet specific learning goals, which include teaching about the importance of Pancasila principles in society.

Development

The study utilizes the Unity 3D application to transform 3D shapes into AR experiences. This involves creating instructional media, having it validated by experts in the subject and media, and revising the educational media based on feedback. Setiawan et al. (2022) stated that learning media is essential for supporting teaching. According to Pagarra & Syawaludin (2022), it includes various forms beyond just printed materials. A key benefit of AR in education is that it can change abstract ideas into real, easy-to-understand examples. (Kartini, 2024). Researchers addressed challenges in Pancasila education at SDN Kalibanteng Kidul 01 by creating physical and electronic media. This includes augmented reality dioramas that explain the meaning of Pancasila precepts in society. Hosch (2021) in Widyaastuti and Suwanto (2022) stated that AR is a process that combines images with digital files. The media includes several parts, like an introduction, menus, profiles of the developer and lecturer, guidelines, learning outcomes, objectives, materials, a bibliography, an AR camera menu, quiz instructions, quizzes, and scores. The outcomes of utilizing AR-based diorama media for Pancasila education emphasize the importance of comprehending the Pancasila principles within society.



Figure 1. Diorama Media



Figure 2. Augmented Reality

Step is to validate the augmented reality diorama media in two stages. The first stage includes a material review by Dr. Tri Astuti and Moh. Fathurrahman as media expert. The validation described in the following section.

Table 1. Media Expert and Material Expert Validation Results

Expert	Total Score	Percentage	Criteria
Media Expert	56	93,33%	Very Feasible
Materi Expert	55	98,21%	Very Feasible

The study shows that the Augmented Reality diorama for teaching about the Pancasila precepts is highly suitable for use. Researchers made changes based on feedback from media and material experts.

Implementation

In the fourth grade at SDN Kalibanteng Kidul 01 in Semarang, we will use media as a teaching tool. Our goal is to see how well it works by looking at the reactions of students and teachers. The effectiveness of the media will be tested using an N-gain test based on the results of student pretests and posttests.

The small-scale trial involved 6 students in class IV who took a questionnaire on critical reasoning. Initially, their average score was 99, which was 51.56%. After using augmented reality-based diorama media, their score rose to 180, reaching 93.75%. Percentage increase of 42.19%. In a study with 23 fourth-grade students, the results of a critical reasoning questionnaire showed that their score before using media was 323, or 43.88%. Subsequent to the application of AR-based diorama media, their score improved 701, which is 95.24%. Percentage increase of 51.36% so that the utilization of augmented reality-based diorama media can improve the critical reasoning dimension of Pancasila education of fourth-grade students at SDN Kalibanteng Kidul 01, Semarang City.

A small trial with six students used augmented reality-based diorama media to study its effects on learning. The pretest average score was 41.6, while the posttest average rose to 92.5. These results show a clear improvement in learning, with an average increase of 50.9 points, demonstrating the effectiveness of this new teaching method. The large-scale trial to compare their learning results before and after using media. At SDN Kalibanteng Kidul 01, the average pretest score was 46.73, while the average posttest score was 87.60, showing an increase of 40.87. The results indicate an improvement in the students' learning.

The next step is to perform a normality test on the students' pre- and post-data to check for normal distribution. The Shapiro-Wilk formula, used in SPSS, will be applied. A significance > 0.050 means the data is normally distributed; < 0.050 indicates it is not.

Table 2. Normality Test Results

Information	Shapiro-Wilk		
	Statistic	Df	Sig.
Pretest	.954	29	.230
Posttest	.938	29	.087

Using SPSS, the significance was 0,230 for the pretest and 0,087 for the posttest. The pre and post test data show a normal distribution.

The next step is to find differences in average pretest and posttest scores using the T test. This will show if there is a significant change from using augmented reality-based diorama media for Pancasila education on understanding the Pancasila principles in society. If $t_{hitung} \geq t_{tabel}$, then H_a accepted and if $t_{hitung} \leq t_{tabel}$, then H_0 accepted. To assess the average difference in student learning outcomes, we conducted a paired sample t-test comparing pretest and posttest scores. The results indicated a significant difference, revealing the effectiveness of augmented reality-based diorama media, as demonstrated by our t-test analysis using SPSS.

Table 3. T-Test Results

Test	N	t-count	t-table	Description	Sig. (2-tailed)	Description
Pretest	29	17,430	2,048	H_a retrieved	<,001	Significant
Posttest	29			H_a retrieved		

The results of the t-test can be summarized as follows $t_{hitung} \geq t_{tabel}$ is $17.430 \geq 2.048$ H_a accepted. Summary of the average pretest and posttest results sig. (2-tailed) is $<,001$. This means that using augmented reality-based diorama media significantly improves the Pancasila learning outcomes for fourth-grade students at SDN Kalibanteng Kidul 01 in Semarang.

The researchers used the N-gain test to calculate the average score increase from pre to posttest. Next section shows the average increase in these scores.

Table 4. N-Gain Test Results

Average Pretest	Average Posttest	Score Maximum	N-Gain	Criteria
45,68	88,62	100	0,7901	High

Data indicated a high effectiveness score of 0,7901. The average score increased by 42,94 points from the pretest to the posttest. This media was effective for teaching Pancasila education about the principles of Pancasila in society.

Evaluation

This stage of the study assesses the effects of implementation, specifically focusing on the evaluation of the outcomes associated with the deployed media. The integration of augmented reality-based diorama media within the educational setting offers a learning experience that significantly diverges from traditional methodologies. This innovative approach promotes a shift from passive absorption to active participation engagement. The results of the teacher questionnaire review showed that all 16 items received a response of "Strongly Agree," with a perfect score of 100%. Meanwhile, the student questionnaire produced a score of 92.96%, indicating that the media is very valid and suitable for use in learning.

Teachers' assessment of AR-based diorama media showed 100% feasibility, while students' responses reached 91.10%, both of which were classified as very feasible. This media has proven effective in helping students understand the meaning of the Pancasila principles in community life.

The latest technology that is interesting, innovative, and interactive, such as AR, has been proven to make a positive contribution to the world of education. AR is able to create a more lively and real learning experience so that it can increase student interest, motivation, and involvement during the learning process. With its ability to visualize abstract concepts more concretely, AR becomes an effective tool in helping to understand the material while enriching the teaching methods used at various levels of education (Yun et al., 2023). AR creates a 3D effect that shows real objects clearly. This helps students understand lessons better and boosts their curiosity for thinking critically (Fitria, 2023).

Moreover, the research conducted by Bistaman et al. (2018) indicates that AR technology has been positively received by elementary schools and educators. This technology enables students to explore virtual environments and emulate real-world experiences, thereby enhancing their comprehension of various concepts (Oberdörfer et al., 2021). AR improves teamwork between students and teachers. It allows students to collaborate with each other in virtual spaces, engage in group activities, and learn together (Al-Ansi et al., 2023). Students who possess critical thinking skills are more inclined to analyze and evaluate ideas thoroughly prior to making decisions (Herianingtyas et al., 2024). A strong curiosity helps create a lively learning environment. Augmented reality-integrated dioramas stimulate students to engage in creative and critical thinking.

At SDN Kalibanteng Kidul 01, fourth-grade students can significantly benefit from these dioramas, as they enhance reasoning abilities, deepen understanding of Pancasila, boost learning motivation, and minimize boredom. The findings of the study align with the research conducted by Zhou et al. (2024), which suggests that augmented reality-assisted experiments offer distinct advantages over traditional methods, particularly concerning safety, cost-effectiveness, and accessibility. AR has also proven to be more effective in helping students understand the material, remember vocabulary better, and retain information that has been learned for a longer period of time when compared to traditional teaching methods (Muangchan & Yanhua, 2025).

Additionally, a study by Pujiastuti & Haryadi (2024) indicates that AR applications are effective, as they enable students to visualize and directly engage with the outcomes of the learning process in real time. The use of AR technology in learning can increase student satisfaction through interesting, interactive, and immersive learning experiences. AR also supports dynamic and participatory learning, especially in the form of educational games. By simulating real situations, AR helps students understand the material more applicatively, develop critical thinking, and strengthen conceptual understanding (Prasittichok et al., 2024). The use of augmented reality-based multimedia has been examined in the works of Sirakaya & Alsancak Sirakaya (2018), Yuliono et al. (2018), and Kurniawan et al. (2018). These studies demonstrate that such technology can aid students in accessing relevant data and information, thereby enhancing their comprehension of materials related to earth and rock structures and subsequently fostering critical thinking skills. Immersive AR-based dioramas equipped with annotations provide a more real, interactive experience for independent exploration and are effective in conveying knowledge communicatively (Harrington, 2020).

In summary, the results of this study corroborate previous research and fortify the assertion that the development of AR-based diorama media is not only pertinent to

contemporary education but also effective in enhancing critical reasoning capabilities and student learning outcomes.

CONCLUSION

Augmented reality-based diorama media serves as an educational resource designed to convey the meaning of the Pancasila precepts to fourth-grade students at the elementary level. This media was created after a thorough needs assessment. Subsequently, it underwent validation by experts in both media and content, receiving commendable evaluations for its quality and appropriateness. During both small-scale and large-scale trials, the media was assessed positively, demonstrating its effectiveness in enhancing students' critical reasoning skills and overall learning outcomes with Pancasila education for fourth-grade students at SDN Kalibanteng Kidul 01 in the city of Semarang. The contribution of this research lies in providing an innovative learning media model that integrates augmented reality with diorama-based learning to support abstract civic values comprehension at the elementary level. Furthermore, this study offers empirical evidence that technology-enhanced, context-based instructional media can foster critical reasoning skills and improve learning outcomes in Pancasila education. The findings also contribute practical insights for teachers and curriculum developers regarding the effective use of augmented reality in character and civic education, particularly in strengthening students' understanding of national values at an early age.

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