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Feasibility of Augmented Reality Integrated E-Comics to Improve Learning Outcomes

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Abstract. Student learning outcomes that have not been maximized can be caused by one of them is the utilization of learning media that is less varied. The use of varied learning media can attract student interest and can affect student learning outcomes. However, in reality there are still many teachers who have not maximized the use of learning media. The main objective of this research is to develop augmented reality integrated e-comics to improve learning outcomes. The research method used is Research and Development research. The development model used is 4D (Define, design, develop, and disseminate). This study involved teachers and 20 fifth grade students. E-comic integrated augmented reality was developed according to the needs of teachers and students obtained from the results of interviews, observations, and questionnaires. The results showed the percentage level of feasibility of e-comic from media experts obtained a percentage value of 90% with very feasible criteria. Assessment of e-comic integrated augmented reality from material experts obtained a percentage value of 80% with decent criteria. The n-gain test result is 0.581 which shows an increase in student learning outcomes. The conclusion is that e-comic integrated with augmented reality can help students improve learning outcomes in IPAS learning.

Keywords: Augmented Reality; E-Comic; Elementary School; Learning Media; Learning Outcomes

1. Introduction

Industrial Revolution 4.0 is the era where the majority utilizes technological developments, including in education. As a means of addressing the issues brought about by the advancement of the Industrial Revolution (era 4.0), the idea of 21st-century education was established. The idea of 21st-century education is a broad notion that serves as a guide for education that is being provided right now (Howard et al., 2019). In its execution, teachers are necessary to be able to use technological improvements, however in the current era, technology is something that is highly primary to learn (Souza & Debs, 2024). With these demands, educators must master the skills to master technology to face the challenges of education (Gómez-Trigueros et al., 2024). The research conducted (Gumennykova et al., 2022) states that the current trend in education must be able to integrate technology into the education process at all levels. Characteristics of students during the Industrial Revolution. 4.0 are more accessible to receive information using technological developments, therefore teachers must be able to package technological developments into learning media (Riyanti et al., 2022).

A tool that can help someone provide information throughout the learning process is learning media (Knaus, 2023). With the utilization of learning media, learning can take place more efficiently and also optimally (Kodrle & Savchenko, 2021). Learning media is an important component in learning at the elementary school level because of the characteristics of students who have limitations in understanding abstract material, according to (Hardiansyah et al., 2023) through learning media the messages that teachers want to convey to students become more efficient and also more effective. Technological developments have created a new educational transformation, with innovations in learning methods and the use of interactive learning media, which, of course, can enrich students' learning experiences (Islam

Sarker et al., 2019). However, in reality, there are still many teachers who have not maximized learning media due to a lack of facilities and teacher limitations in applying learning media (Puspitarini & Hanif, 2019).

1.1. Problem Statement

The learning content of IPAS emerged after implementing the independent curriculum in the current education system in which the science learning content was unified with social studies learning(Surul & Septiliana, 2023). IPAS education in the independent curriculum is intended so students can develop inquiry skills, understand the environment and themselves, and develop their knowledge and concepts in learning (Komariah et al., 2023). The urgency of IPAS Education is that through IPAS learning, students will be able to develop their potential in the form of developing self-knowledge, being active, caring for the environment and themselves, developing inquiry knowledge and can foster student curiosity about IPAS learning (wanti & Chastanti, 2023). Implementing independent curriculum subjects gives students the freedom to explore, innovate, be active, and have student-centered learning (Akbar et al., 2024). Ideal IPAS learning in the current era must be interactive, integrative, and technology-based, encouraging students to think critically, creatively, and collaboratively.

However, in reality, this cannot be separated from the obstacles and problems faced in the learning process. Based on the findings from observations and interviews with the fifth-grade teacher of SDN 2 Wanaraja, the use of technology-based learning media is in the form of power points and learning videos per the material being discussed. In the learning outcomes shown by students, it was found that there were still many students who repeated when carrying out daily tests; this could be due to a lack of student focus in learning and an understanding of the concept of material that had yet to be maximized. As for interviews conducted with several fifth-grade students, students tend to need help answering questions about the IPAS material that has been taught. This fact shows that students' mastery of the IPAS material concept still needs improvement. The learning that is carried out also tends to be teacher-centred students do not actively participate during the learning process. The lack of interest in learning from students is directly proportional to the level of understanding of student material because student interest in learning can increase motivation so that student learning outcomes can increase (Sutarto et al., 2020), this is also closely related to the lack of innovation by teachers in learning.

One solution to the above problems can be to use learning media that can straighten out the complex concepts that arise from IPAS subjects. In teaching it, an innovative and creative approach is also needed to help students understand the material better (Sinaga et al., 2019). An innovation in learning media is the development of an e-comic integrated with augmented reality. An e-comic integrated with augmented reality is an electronic learning media containing learning materials on specific topics equipped with images, text, video, audio, and 3-dimensional characters.

Based on this background, researchers are motivated to develop E-Comic learning media integrated with Augmented Reality (AR) in IPAS class V Elementary School subjects because, according to researchers, learning through smartphone media will be more practical to do anywhere and anytime, so it can make students more accessible to learn (NIWAS, 2020). Researcher have also analyzed the needs of students and teachers, which aims to determine how high the needs of students and teachers are related to the development of e-comic integrated augmented reality that researchers develop. Based on the results of the analysis, 18 out of 20 students are interested in using e-comic integrated augmented reality as a learning media used in IPAS class V subjects. The results of this need analysis are also one of the bases for researchers to choose to develop e-comic integrated augmented reality as a learning media.

1.2. Related Research

This material was developed based on the findings of earlier studies, including research conducted by (Surya et al., 2020). The title "The Effectiveness of the Use of Digital-Based Educational Media in Improving Reading Interest" states that digital comic media is efficacious

in improving reading interest. Research conducted by (Mustikasari et al., 2020) The title "The Development of Digital Comic on the Ecosystem for Thematic Learning" shows that e-comic development can increase student interest and motivation in thematic learning. Research conducted by Prihandini & Siswati (2022) The title "Development of Thematic E-Comic Based on Augmented Realityl" shows the results of e-comics effectively increasing student interest in learning.

The renewal of research conducted by researchers with previous research is the development of augmented reality integrated e-comics developed by researchers to raise regional cultural heritage in the Banjarnegara area. The e-comic plot is structured with a storyline that highlights the cultural heritage of Banjarnegara such as the Kramik Klampok craft center, the Arjuna Temple tourist complex, Dawet Ayu, and the specialty food from Banjarnegara, namely Carica Dieng. In addition, in the research process, researchers refer to cognitive learning theory, according to Jean Piaget. Learning by involving local wisdom can help students foster virtuous character and can create a noble character (Uge et al., 2019)

1.3. Research Objectives

The purpose of this research in the context of utilizing technology-based learning media to improve student learning outcomes. The main objective of this research is to improve student learning outcomes through the development of augmented reality integrated e-comic media. By testing the learning outcomes of students before using e-comic integrated augmented reality with the learning outcomes of students after using e-comic integrated augmented reality.

2. Theoretical Framework

2.1. Cognitive Learning Theory Jean Piaget

According to Piaget, cognitive development is based on biological mechanisms of nervous system development and is influenced by age. According to Piaget, a person will learn according to the development stage corresponding to his age. This stage is stratified and passed in accordance with a specific sequence, a person cannot learn something outside his stage of cognitive development. According to Piaget (Kazi & Galanaki, 2020) , there are four phases of children's cognitive development: 1) Sensorimotor Phase: Children aged 0-2 years use their innate reflexes that have existed since birth to explore the world; 2) Preoperational Phase: Children ages 2 to 7 improve their abilities; and 3) Preoperational Phase: Children ages 2 to 7 improve their abilities.

2.2. Education for the 21st Century

Education is essential in the 21st century. Education in the 21-first century may ensure that students have skills such as creativity, the capacity to use technology and information media, and the ability to survive by relying on life skills (González-pérez & Ramírez-montoya, 2022). 21st-century learning emphasizes students' ability to think analytically, work collaboratively, solve problems, and obtain information from various sources (Herlinawati et al., 2024) In implementing it, teachers are required to use technological developments, which is very important in the current era.

2.3. E-comic Learning Media

According to (Wareing & Ferguson, 2024), comics are works of art that use non-moving illustrations arranged systematically to form a coherent storyline to convey a message. The form of comic adaptation from the development of technology and informatics, now comics are also presented in digital or electronic form, known as e-comic. In the world of education, electronic comic media has several advantages, namely: a) Make it easier for students to understand the ongoing learning material, b) Add students' insights into understanding the material, and c) as an exciting and entertaining educational tool, d) Increase student interest in learning.

2.4. Augmented Reality in Education

Augmented Reality is one of the Artificial Intelligence that is designed to be able to display 3-dimensional shapes into the real world clearly (Petrov & Atanasova, 2020). Using Augmented Reality (AR) as an interactive learning media, augmented reality allows students to interact with 3D objects that are difficult to reach in the real world. Involving students directly in the learning process can increase student learning motivation. This is because learning can provide a significant experience for student (Rhea & Bauml, 2020). The benefits of using augmented reality in education include several things, namely: it can present engaging and exciting content through virtual elements, allowing learners to gain new learning styles through hands-on experience and strong visual displays, and can encourage learners to be able to collaborate, improve problem solving and be able to think critically (Afnan et al., 2021).

2.5. Student Learning Outcomes

Learning outcomes can be interpreted as the results achieved by students after going through the learning process, which is shown through the scores obtained by students (Erikson & Erikson, 2019). According (Burke et al., 2024) two types of factors can affect students' learning outcomes: internal factors and external influences.

a. Internal Elements Learners' internal variables influence their learning capacity. Intelligence, focus and interest, learning motivation, persistence, attitude, study habits, physical state, and health are some of these internal elements.

b. The home, the school, and society are external influences that impact students' learning outcomes. Family conditions also impact student learning results.

3. Method

3.1. Research Design

The research and development (R&D) approach is used to create specialized goods and evaluate their efficacy. The resulting product requires research or a needs analysis to determine its usefulness in education. Learning technology is directly tied to research and development methods. Learning technology research has interacted with product development and design concerns, particularly those related to media, teaching materials, and learning systems. As a result, the goal of this research is to create learning media that are tailored to the needs of students. In this study, the development model is based on Thiagarajan's 4D (four-dimensional) research and development paradigm, which includes define, design, develop, and disseminate (Yusuf, 2023)

Researcher adopt this approach because of its structured stages. The distribution step aligns with the conceptualization of the topic to be studied, namely measuring the effectiveness of the e-comic development product produced. In addition, the 4D model emphasizes continuous development and revision, ensuring that learning materials are tested and refined before being disseminated. This can improve the final quality of the learning product.

3.2. Respondent

A total of 20 5th grade students of SD Negeri 2 Wanaraja, consisting of 12 female students and 8 male students became research subjects with an age range of 11-12 years. Students' learning styles are dominant with visual learning styles with characteristics of students who more easily understand material through the display of images, videos, and other visual media. The majority of students are proficient in operating smartphones as a medium to support learning.

3.3. Data Collection

The data collecting methods employed by researchers in this study are: 1) questionnaires, which researchers gave to experts, and also students 2) documentation, the documentation method in this study was used to obtain the names of students, the number of students, the list of report cards, implementation photos, media development questionnaire data, expert validation questionnaire data, learning outcomes data on product trials 3) Tests are used to

measure the essential abilities and achievements of student performance and see the effect of the e-comic development carried out by researchers. The lattice of data collection instruments can be seen in Table 1, Table 2

Table 1. Material expert assessment instrument lattice

Aspect	Question Number	Number of question
Self Instruction	1,2,3,4,5,6,7,8	8
Self contained	9,10,11	3
Stand Alone	12,13	2
Adaptive	14	1
User Friendly	15	1

Table 2. Grid of media expert assessment instruments

Aspect	Indicator	Question Number	Number of question
Appropriateness	Media in accordance with the learning topic	1,2,3	3
Display	The design of the display that seen is interesting	4,5,6	3
	Quality of media display	7,8,9	3
Usage	Media is easy to use by students and teachers	10,11,12	3
Advantage	Media can be understood by users	13,14,15	3

3.4. Data Analysis

The data in this study will be analysed descriptively qualitatively. The data analysed includes the feasibility of learning media, learning outcomes scores. Qualitative assessment of learning media is done through checklist assessment. The results of research from expert lecturers in the form of product quality are coded with a qualitative scale and then converted qualitative values into quantitative values with the following provisions: very good (4), good (3), less (2), significantly less (1) then the values obtained are summed up from each indicator. Assessment of validity, effectiveness, and learner response is done through distributing questionnaires.

Percentage of validity = $\frac{Score\ Obtained}{Ideal\ Maximum\ Score} X\ 100\%$

Based on these data, we then interpreted according to the range in Table 3.

Table 3. Assesment Criteria Tabel

Interval	Criteria
85%-100%	Very Feasible
76% - 84%	Feasible
60% - 75%	Feasible enough
55% - 59%	Less feasible
<54%	Not Feasible

3.5. Validity and Reliability

The validity test is used by researcher to test the instruments used in research are valid and function properly (SÜRÜCÜ & MASLAKÇI, 2020). In this study, the validity test was used to test questions that would later be used for pretest and posttest questions. The validity test uses the following formula

$$\text{rpbi} = \frac{Mp - Mt}{St}\sqrt{\frac{p}{q}}$$

where:

rpbi: biserial correlation coefficient

mp: the calculated averages score for items answered correctly

mt: average score of the total score

p: proportion of students who answered correctly on the item being tested for validity

q= the proportion of students who answered incorrectly on the item being tested for validity

Of the 60 questions tested for validity, only 20 were considered valid and could be tested during the study because the calculated rpbi of 20 questions obtained rpbi ≥ 0,3. This research instrument was found to be valid, typically homogeneous, and suitable for use as a measuring instrument.

4. Findings

The researcher presents the research results conducted on August 9 and 10 2024, at SD Negeri 2 Wanaraja. This research took place over 2 (two) meetings, 1 (one) meeting for the pretest and teaching and learning process, and 1 (one) meeting was used to administer the posttest. The experimental class was class V. This research was conducted by the researcher, who acted as a teacher.

From the results of the research that has been carried out, the researcher presents the results in the form of 1) the results of validation of augmented reality integrated e-comic development; 2) results of analysis of the improvement of student learning outcomes after using e-comic media; 3) the results of the analysis of the effectiveness of augmented reality integrated e-comic development.

4.1. Define

This stage includes data from a series of needs and facts in IPAS learning at SDN 2 Wanaraja. The defined stage goes through several stages, namely:

a. initial final analysis, namely activities carried out to find problems that exist in schools. The implementation of this activity was carried out on January 19, 2024,

b. learner analysis, researchers observed students during the learning process and found problems in the form of students' lack of interest in learning,

c. concept analysis (concept analysis) researchers are analyzing IPAS class V semester II material. Researchers then narrowed down the IPAS CHAPTER 7 material with the theme My Pride Region, while the concept of the e-comic that will be created is specific to the development of e-comic cultural heritage of the Banjarnegara region,

d. task analysis: At the task analysis stage, the researcher analyses the tasks students must master to achieve learning achievement indicators. The tasks given to students in this study are worksheets and evaluation tests, analyzed based on the learning objectives listed in the Class V teaching module topic A My Pride Region.

e. Formulation of learning objectives (specifying instructional objectives): The learning objectives that must be achieved in the development of the Banjarnegara cultural heritage e-comic have been obtained from the concept analysis. The formulation of learning objectives on topic A of my proud region is based on the IPAS Class V teacher's book.

4.2. Design

This stage aims to produce an e-comic development design that will be developed. The preparation of an e-comic integrated with augmented reality (AR) refers to outcomes of the analysis carried out during the defining stage. Researchers take this stage by doing two activities: 1) Preparation of reference tests; this study used two tests in product trials, namely pretest and posttest. 2) Based on observations, interviews, and needs analysis, the researcher decided to create an e-comic with augmented reality to improve the learning outcomes of fifth-grade students in IPAS topics. 3) Initial design, at this stage researchers compile teaching modules and also e-comic integrated augmented reality.

4.3. Development

The development step strives to create the final shape of the e-comic product development after going through revisions based on expert input. The development stage comprises media expert assessments, material expert validators, and product development tests. The results of e-comic development can be seen in Figure 1, Figure 2, and Figure 3.

Figure 1. Cover E-comic

Figure 2. Button Menu

Figure 3. Cultural Heritage e-comic

The e-comic products developed were then assessed by material and media experts, the results of which can be seen in Tables 4 and 5.

Table 4. Material Expert Assessment Analysis Results

Assessment Aspek	Maximum Score	Score	Percentage	Criteria
Self-Instruction	32	25	78%	Feasible
Self-Contained	12	10	83%	Feasible
Stand-Alone	8	6	75%	Feasible
Adaptive	4	4	100%	Very Feasible
User-Friendly	4	4	100%	Very Feasible
Total	60	49	81%	Feasible

Based on the overall material assessment criteria, with a score percentage of 80%, the development of e-comic integrated augmented reality is considered feasible.

Table 5. Media Expert Assessment Analysis Results

Assessment Aspek	Maximum Score	Score	Percentage	Criteria
Suitability	12	11	92%	Very feasible
Display	24	22	92%	Very feasible
Usage	12	11	92%	Very feasible
Advantages	12	10	83%	Feasible
Total	60	54	90%	Very feasible

Based on the overall media assessment criteria, with a score percentage of 90% the development of an e-comic integrated with augmented reality gets the predicate "very feasible." The e-comic product developed then received revisions from media experts, including adding identity to the e-comic cover page, which can be seen in the figure 4 and 5

Figure 4. E-comic Before Revised

Figure 5. E-comic After Revised

The revised product was then tested using two stages: small-scale product testing and large-scale product testing. Researchers conducted the small-scale product test to test the obstacles found from the use of e-comic before the media was applied to a more significant number of respondents. The trial results were used as evaluation guidelines for researchers to develop media by minimizing errors that might occur. The results of the small-scale trial were conducted with five students.

Table 6. Result of the Small-Scale Trial

Action	Average	Highest Score	Lowest Score	Students Completed	Students Not Completed	Learning Completeness (%)
Pretest	58	80	45	1	4	20%
Posttest	85	100	75	5	5	100%

Table 7. Result of the Large-Scale Trial

Action	Average	Highest Score	Lowest Score	Students Completed	Students Not Completed	Learning Completeness (%)
Pretest	70,3	100	40	10	10	50%
Posttest	88,5	95	75	20	20	100%

Table 4 shows that student learning outcomes in small-scale product trials increased by 80%, and Table 5 shows that students' learning outcomes increased by 50% in the large-scale product trial. Researchers then used these results to conduct the n-gain test, which shows the increase in student learning outcomes before and after using e-comic. The n-gain test results can be seen in the table 8.

Table 8. N-Gain Test Result

Activity	Action	Number of Learners	Average	Difference Average	N-gain	Criteria
Small scale trial	Pretest	5	58	27	0,647	Medium
	Posttest	5	85			
Large Scale Trial	Pretest	20	70,3	18,2	0,581	Medium
	Posttest	20	88,5			

Based on Table 6, the n-gain test results for the small-scale product trial showed an n-gain result of 0.581, while the large-scale product trial showed an n-gain test result of 0.581, which was in the "feasible" category. Therefore, e-comic media proved to be feasible in improving student learning outcomes.

4.4. Media Effectivity Test Results

To evaluate the effectiveness of an augmented reality integrated e-comic created by the researcher. The t-paired test was used by the researcher to calculate the significance value of the pretest and post-test results. The data tested had to be normally distributed after the normality test using the Kolomogrov-Smirnov formula. The pretest and post-test data were normally distributed. The t-paired test indicates the efficiency of a product if the pretest and posttest variables have a significance level of <0.05 (2-tailed). Table 9 displays the results of the t-paired test used to assess the effectiveness of e-comic integrated augmented reality.

Table 9. t-paired test results

Sample	t-Test Result sig. (2-tailed)	Significance level	Description (sig < 0,05)
Pretest-Posttest	0,001	0,05	there are differences

Based on Table 14, the Sig W (2-tailed) significance level of 0.001 < 0.05, it is possible to conclude that variable 1 is significant, namely the pretest value and variable two namely the posttest value which shows that the development of e-comic integrated with augmented reality is effective for improving the learning outcomes of grade V students in IPAS subjects at SDN 2 Wanaraja.

5. Discussion

The product results of the development research conducted by researchers are augmented reality integrated e-comics. The development of e-comic integrated augmented reality is based on the problems found by researcher during observations and interviews with fifth-grade teachers at SDN 2 Wanaraja. The problems found in the utilization of technology-based learning media that has not varied, and the interest in learning shown by students during learning tends to be less enthusiastic. Using current difficulties, researchers are interested in designing learning media that can boost students' interest in learning, because learning interest shows a relationship with student learning outcomes (Liu et al., 2022).

The research that has been done shows that the results of e-comic integrated augmented reality is feasible and can be used as learning media. This is due to several factors, namely as follows: First, the e-comic is appropriate based on the needs analysis with the developed model, namely the 4D model based on theory and arranged systematically. Thiagarajan's 4D development model is a reference for researchers to develop e-comic integrated with augmented reality. During this 4D development stage, researcher can create items that are viable and can aid students' and teachers' learning processes. In addition, research findings from (Fianto et al., 2023) Recommend e-comic as a practical learning media to improve student learning outcomes. The study found that employing e-comics can boost students' enthusiasm in learning (Udayani et al., 2021). The augmented reality integrated e-comic developed can assist students in learning besides that e-comic also helps students to understand the material better. The use of simple learning media tends to make students quickly bored and less interested in the learning delivered by the teacher (Balakrishna, 2023). The results of the research on the development of e-comic integrated with augmented reality obtained a percentage value of 90% from media experts in the "very feasible" category and obtained a percentage of 80% from material experts in the "feasible" category. In connection with the formulation of the problem that the researchers described regarding the media developed can improve learning outcomes, this is evidenced by an increase in the n-gain test of 0.581 in the large-scale product trial. The results of the effectiveness test show a significance value of 0.001 which shows that e-comic integrated with augmented reality is effectively used to improve student learning outcomes. This is in line with research conducted by (Susanto et al., 2024) with research results that show the significance of posttest scores between control and experimental classes.

Second, using e-comic integrated with augmented reality in learning can improve understanding and strengthen students' memory by helping them understand the material in e-comic related to daily life. E-comic integrated with augmented reality is designed in such a way as to display images, text, audio, video, and 3-dimensional characters in one unit so that it can provide attraction to students by learning using audio-visual media (Yulisa & Diarti, 2024). E-comic media is an audio-visual media that can present material more interestingly, and can present material in a more concrete form so that students can more easily absorb the material being taught (Lestari et al., 2021). Integrating augmented reality into e-comics is also an alternative to be able to increase students' understanding of the material, because the use of augmented reality can visualize abstract concepts to increase understanding (Subhashini et al., 2020).

The three e-comic media developed refer to Jean Piaget's cognitive learning theory. Learning theory, according to Jean Piaget allows learning that provides opportunities for students to be actively involved in learning (Kouicem, 2020). This is certainly in line with the implementation of the independent curriculum which centers learning on students. The implementation of cognitive learning theory, according to Jean Piaget in this study, is at the stage of the concrete operational phase where the development of augmented reality integrated e-comic can provide a concrete and interactive learning experience, helping students understand abstract concepts through visualization and digital manipulation that supports better understanding. Children become more adept at solving concrete problems at the concrete operational stage. Augmented reality integrated e-comic can present engaging problem-solving scenarios, where students must think critically and use their knowledge to solve challenges presented visually and interactively.

Previous research findings state that using e-comics can increase students' enthusiasm for learning, besides e-comics also allow the growth of positive characters that children imitate from the characters contained in e-comic (Suma et al., 2024). Previous research findings state that e-comics can improve elementary school students' creativity skills (Istiq'faroh et al., 2020). The advantages of the developed e-comic are that the e-comic is specifically designed to contain cultural heritage in the Banjarnegara area, which allows students to understand more quickly because it is related to everyday life. In addition, the e-comic is equipped with 3-dimensional characters that can provide new learning experiences to students, as well as

learning videos and evaluation questions that can measure students' understanding of the material. This research implies that e-comic can improve student learning outcomes.

6. Conclusion

The utilization of technology-based learning media is one of the new educational trends in the era of the industrial revolution 4.0 which can affect the interest as well as the learning outcomes of students. Student learning outcomes are a problem highlighted by researchers, because student learning outcomes are closely related to the level of student understanding of the material being taught. The product developed is an augmented reality integrated e-comic. The development of e-comic is based on the problems found by researchers when conducting pre-research, namely student learning outcomes that have not been maximized and the utilization of technology-based learning media that has not varied. In addition, the development of e-comic integrated augmented reality is based on a needs analysis which states that 18 out of 20 fifth grade students are interested in using e-comic integrated augmented reality as a learning medium in IPAS subjects. The results of development research conducted by researchers in the form of E-comic integrated with Augmented Reality in IPAS subjects show an increase in student learning outcomes before using e-comic media and after using e-comic this is evidenced by an increase in the average student learning outcomes this is in accordance with the objectives of this study which is to improve student learning outcomes. In addition to being able to improve student learning outcomes, the e-comic media that has been developed obtained an assessment of media experts and material experts with a very feasible category.

This research was conducted at SDN 2 Wanaraja in IPAS subjects by developing e-comics that refer to the regional culture of Banjarnegara. The results of e-comic development research are considered effective for improving learning outcomes and are suitable for use as supporting media in IPAS learning in elementary schools.

Limitation

In the research process, of course, researchers found limitations, among others: the use of e-comic media integrated with augmented reality is new to fifth-grade students of SDN 2 Wanaraja, therefore some students tend to need clarification about the operation of e-comic. In addition, some students' smartphones do not support the e-comic application developed by the researcher, so students have to use e-comic together with their classmates. This has an impact on the less than optimal utilization of e-comic to be able to support the learning process. Some students are also too enthusiastic about using the e-comic developed, so students tend to focus less on the instructions given by the researcher.

Recommendation

Several findings from the research can be explored, along with recommendations for involved parties and future research: The developed program is designed for cross-platform compatibility, allowing installation on Android, Windows, and iOS devices. This strategy not only aims to reduce the complexity and technical constraints often encountered during the installation process of electronic comic applications, but also to optimize the widespread use of technology-based media. Thus, it is expected that students in the future will have better skills in operating various types of technology-based learning media, which in turn will improve the effectiveness and efficiency of the learning process. In addition, this cross-platform compatibility is expected to encourage wider adoption of technology in educational contexts, ensuring that all students, regardless of their device type, can access learning materials quickly and effectively.

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Conflict of Interest

There is no conflict of interest in this research

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