

Effectiveness of Augmented Reality Based Learning Media to Improve Critical Thinking Skills on IPAS Material

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Abstract: Technology in the 5.0 revolution is developing very rapidly so it is necessary to prepare the student to face the challenges of the 21st century by having 21st century skills, namely critical thinking. Having a low category of critical thinking because the teacher in using the media has not facilitated students to think critically tends to be monotonous and boring. The purpose of this experiment is to establish the effectiveness of AR media to improve learners' critical thinking skills on IPAS material. The study used quantitative research methods with the research type true experiment with pretest-posttest control group design. The data collection methods used are test instrument. The results of the study were tested Independent T-Test to find out the enhancing students' critical thinking skills then conducted an effectiveness test to determine the effectiveness of the application of Augmented Reality-based learning media to improve critical thinking skills on IPAS material. The research results of the average value of the experimental class using AR media are 58.92 and 75.98 while the average value of the control class using conventional media is 58.80 and 63.56. The test results of the Independent Sample T-Test obtained with a value of 0.000 with the provisions of the test decision if significant less than 0.05 then there is sig. effects among the experimental and control posttests. The effective test using N-Gain obtained a result of 56.52 which was categorized as sufficient. It is synthesized that AR-based learning media improves critical thinking skills and the effectiveness of AR-based learning media is effective to use with the N-Gain test.

Keywords: Augmented reality; Critical thinking; Effectiveness

Introduction

Technological developments in the industrial revolution 5.0 is so rapid that it cannot be denied that education faces challenges to continue to innovate and utilize technology. Asrizal et al. (2023), it was stated that information technology and human science are developing rapidly in the 21st century, so educators stated that they must adapt to these changes in the learning process. The globe of education is certainly a responsible field in addressing the changes, demands and challenges of life in the 21st century (Parani et al., 2023). To prepare students for the demands of the 21st century, educators must make changes in the teaching

process. The need to adapt to technological developments and have 21st century skills. One of the abilities that must be possessed is the ability to think critically. Onoda (2022), says that critical thinking skills are cognitive abilities that include evaluation, analysis, reasoning, inference, and problem solving, in addition facilitate learning because it helps learners face new and unexpected experiences. Critical thinking skills are assessing reality and then formulating decisions based on the evaluation of available information and data analysis. Capacity assess reality formulate conclusions based on evaluation of information and analysis of available data (Alismaiel, 2022). The reality in the field at SD Negeri Kota Magelang shows that critical thinking

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skills are still low as evidenced by the low percentage of 30-45% only, supported by the results of the average score of 60.96 even though educators have used High Order Thinking Skills (HOTS).

PISA results, Indonesia ranked 64th from 65 countries with a literacy score of 382. There are six levels of questions used six levels of questions used (the lowest level 1 and the highest level 6). In addition, Indonesian students according to (Florea & Hurjui, 2015), it is proven that the learning that is usually done capabilities to think critical is still low. Based upon this, there is a need for innovation from teachers to facilitate student, especially in the use of technology (Haleem et al., 2022). For this reason, an educator needs to prepare for learning as much as possible.

Learning plays an important role in education. Learning is a teacher activity to convey knowledge, understanding, skills and attitudes to students Learning is the student and teacher interaction through learning resources environments (Ong & Quek, 2023; Sun et al., 2023). Learning is said to be successful if the learning objectives are achieved. Achieve learning objectives, it needs to be supported by learning activities. Teachers are part of the key to learning process for create a sense of fun and conducive to learning, in order to reach learning goals (Monteiro et al., 2021; Nadeem et al., 2023). The elementary school learning process implements learning by emphasizing students are active during learning (Parker et al., 2022). Education requires a foundation using a curriculum because it is an important element as the main guide in learning (Darling-Hammond et al., 2020). The curriculum is a series of learning plans that students must take so that the education curriculum is dynamic (Cholilah et al., 2023). The curriculum implemented in Indonesia today is the Merdeka Curriculum. The implementation of the curriculum is in accordance with the decree of the Minister of Education, Culture, Research and Technology of the Republic of Indonesia Number 56/M/2022 concerning guidelines for curriculum implementation in the context of learning recovery. This curriculum makes an alternative in overcoming learning setbacks during the pandemic (Dayagbil et al., 2021).

Method

This study applies quantitative research methods. The research type utilized is Experimental Design. According to Singh (2021), there are several experimental designs, namely pre-experiment (non-design), true-experimental, facrorial experimental, and quasi experimental. Researchers chose true-experiment design with the type of research design in this category is the pretest-posttest control group design, Table 1.

Table 1. The Pretest-Posttest Control Group Design

| Class | Pretest | Treatment | Posttest |
|-------------|----------------|----------------|----------------|
| Eksperiment | 0 ₁ | X ₁ | 0 ₂ |
| Control | 0 ₁ | X ² | 0 ₂ |

This study was carried out with fifth grade students of SDN Kemirirejo 3 and SDN Kramat 4 Kota Magelang. The division into two classes, the experimental class used as many students as 56 and the control group amounted to 25 students. The research sample using purposive sampling. Collection technique with test instruments that had been validated by experts and had been tested in upper grades, reliability, level of difficulty, and differentiability. The use of this test instrument to determine critical thinking skills because the test instrument has been designed based on HOTS customized critical thinking indicators. Then the data obtained is tested Independent T-Test to know increase in the ability of students to think critically and test the effective of using the N-Gain test as a measuring tool the effective of AR-based media of AR media on the critical thinking skills in elementary school science materials. The g-factor formula of N-Gain according Lismaya et al. (2022).

$$N\ Gain = \frac{Skor\ Posttest - Skor\ Pretest}{Skor\ Ideal - Skor\ Pretest} \quad (1)$$

Using the interpretation of the effectiveness of N-Gain with percentage categories Table 2 (Wardoyo et al., 2020).

Table 2. Effectiveness Interpretation N-Gain

| Percentage | Interpretation |
|------------|----------------------|
| < 40 | Not Effective |
| 40 - 55 | Less Effective |
| 56 - 75 | Moderately Effective |
| > 75 | Effective |

Result and Discussion

Result

First, this testing is done by applying the T test to effectiveness of which is better by comparison the experimental class that uses AR media in IPAS learning with control class that does not apply AR media in IPAS learning. The requirement before conducting the effectiveness test is that the dependent variable value must be a normal and homogeneous distribution. The precondition test is done out before conducting T test. This test is to measure the efficacy of AR-based media on the critically thinking skills of primary school students. The prerequisite test includes three stages as follows.

Normality Test

The data has the aim of detecting distribution of data in one variable that will be used in research. Normal distribution if the data produced is good and feasible to prove the research model. Data analysis was carried out with the Kolmogorov-Smirnov using the assistance of SPSS version 25, which has sig level of 0.05. When p value > 0.05 the data is normal in its distributions and vice versa. The normality test can include viewed in Figure 1.

| Kelas | Kolmogorov-Smirnov ^a | | | Shapiro-Wilk | | |
|--------------------------|---------------------------------|------|------|--------------|------|------|
| | c | df | Sig. | Statistic | df | Sig. |
| Critical Thinking Skills | PreTest Eksperimental | .103 | 56 | .200* | .976 | .319 |
| | Post Test Eksperimental | .111 | 56 | .086 | .954 | .031 |
| | Pre Test Control | .146 | 25 | .176 | .950 | .248 |
| | Post Test Control | .158 | 25 | .108 | .962 | .446 |

Figure 1. Normality test

Based on Figure 1, test score in the experimental class of the value Kolmogorov-Smirnov test score because the sample used is more than 30 so that the experimental class pretest test results are 0.20, experimental class posttest testing is 0.08. Test results in the control class from the results Shapiro-Wilk test, using this test because the sample used is less than 30. The results of the Shapiro-Wilk pretest test for the control class were 0.24 while the control group posttest test was 0.44 It can be synthesized that the normality test results obtained show normality distributed data because the p-value > 0.05.

Homogeneity Test

Data processing using Levene's Test. The decision basis is that if the significance of the measured data is greater than 0.05, then the data variance is declared homogeneous while less than 0.05, the data variance is declared inhomogeneous with a level of significance of 0.05. This test is applied to determine whether the variants of a number of research populations are uniform or not. The score of the analysis using the SPSS version 25 assistance program can be seen in Figure 2.

| | | Levene Statistic | df1 | df2 | Sig. |
|--------------------------|--------------------------------------|------------------|-----|--------|------|
| Critical Thinking Skills | Based on Mean | .434 | 1 | 79 | .512 |
| | Based on Median | .368 | 1 | 79 | .546 |
| | Based on Median and with adjusted df | .368 | 1 | 78.866 | .546 |
| | Based on trimmed mean | .425 | 1 | 79 | .516 |

Figure 2. Homogeneity test results

Figure 2 getting the price of Levene Statistic Based on Mean obtained a significance of 0.51 > 0.05, so it can be synthesized that the two classes are homogeneous or the variants of the research population are uniform or come from the same variant.

Balance Test

The balance test is needed to test the data on the average score of the two classes in a balanced state. The data used is the pretest value of critical thinking. The following are the results of the pretest value test uses the Independent Sample t-test in Figure 3.

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|------------------------------------|-----------------------------|---|------|------------------------------|--------|-----------------|-----------------|-----------------------|---|-------|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| Critical Thinking Skills (Pretest) | Equal variances assumed | .123 | .727 | .273 | 79 | .786 | .793 | 2.904 | -4.986 | 6.572 |
| | Equal variances not assumed | | | .263 | 42.259 | .794 | .793 | 3.019 | -5.298 | 6.884 |

Figure 3. Balance test results

Figure 3 significant value (2-tailed) in the table with equal variances assumed obtained Sig value. 0.78. The test decision if the Sig. value is less than 0.05 so here is a sig. value greater than 0.05 then there is no sig. value greater than 0.05 then there is no sig. value greater than 0.05 then there is no sig. value greater than 0.05 then there is a meaningful change in the difference between pretest of the experimental and control class. The balance test results have a value of 0.78 > 0.05, then we can conclude the experimental class as well as the control class has no difference so that the two populations are in a balanced state or between the experiment and control class have the same or equal ability.

Hypothesis Testing

The hypothesis testing as to determine the comparison of the critical thinking ability data a two class students so that the independent sample t-test and effect size test are needed.

Independent Sample T-Test

This test is to find out the different critical thinking skills between a two classes by conducting the Independent Sample T-Test test. The following are the results with the help of SPSS version 25 in Figure 4.

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|-------------------------------------|-----------------------------|---|------|------------------------------|--------|-----------------|-----------------|-----------------------|---|--------|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| Critical Thinking Skills (Posttest) | Equal variances assumed | .434 | .513 | 6.459 | 79 | .000 | 14.175 | 2.195 | 9.806 | 16.862 |
| | Equal variances not assumed | | | 6.573 | 48.179 | .000 | 14.175 | 2.156 | 9.840 | 17.170 |

Figure 4. Independent sample t test results

Figure 4 obtained a significance value of 0.00, so, it is hypothesized that there is a significant change

between the posttest of the experimental class and the control class as evidenced by the increase in critical thinking skills in the experimental class by using the experimental class. AR-based learning media compared to the control class using conventional media.

Effectiveness Test

After that, an effectiveness test is done to find out effectiveness of the media. This test was conducted with the help of SPSS version 25 so as to produce the values in Figure 5.

| Component | Experimental Class | | Control Class | |
|---------------|--------------------|----------|---------------|----------|
| | Pretest | Posttest | Pretest | Posttest |
| Average score | 58.92 | 75.98 | 58.80 | 63.56 |
| Gain Score | 56.527 | | 25.162 | |
| Category | Less | | Not | |

Figure 5. N gain

The application of AR media improves students' critical thinking skills, because the mean score of the posttest in the experimental class is higher. The posttest value of the experimental class has an average of 75.98, while the average posttest value of the control class is 63.56, it is said that there is a significant difference. The outcome of the N-Gain score is 56.52 which is included in the moderately effective category. It is concluded that the use of AR-based learning media is quite effective in enhancing the critical thinking skills of students elementary school students, especially on the material IPAS.

Discussion

Learners are given wider space to optimize their exploration of concepts and competencies in this independent curriculum (Pho et al., 2021). The emergence of IPAS subjects occurred in this curriculum with the Pancasila Education Strengthening Project (Rahmawati et al., 2023). In accordance with (Mutiaras As'Zaroh & Diah Utami, 2023), that in this curriculum IPAS is a new subject and plays a role in realizing the profile of Pancasila students. One of the contents contained is Natural Science (IPA). Natural Science provides an opportunity for every student to hone their curiosity scientifically and is expected to be able to apply it to life. Science is a science related to natural phenomena presented regarding facts, concepts, principles and laws whose truth is tested in a series of activities (Nanglu et al., 2023). Science is also defined as mastery of a set of knowledge related to facts, concepts or principles (Suwono et al., 2017). Concepts in science in elementary school are arguably classified as integrated cause they have not been separated such as physics, chemistry, and biology. So that the teacher refers more to the objectives to be achieved (Markula & Aksela, 2022).

The goal of science is to understand scientific concepts and students can apply them in everyday life. Providing explanations not everything can be conveyed and applied in everyday life the teacher needs an intermediary. Especially in the digestive system material, teachers need visualization of each organ in the digestive system. The reality in the field of learning media applied in elementary schools in Magelang city is still mostly conventional. The application of the media tends not to facilitate learning well because the media in the digestive system material applied in the form of pictures, mannequins and videos with too long a duration that causes boredom in learning. Opinion Dwivedi et al. (2023), also said that conventional learning media has limitations when presented in the form of text or images that are not enough to attract students with various learning styles, besides that the actuality and renewal of information is limited. Coman et al. (2020), stated that conventional media tends to be more limited in terms of interactivity and flexibility in delivering information to students, because conventional media can be said to be a traditional concept of learning, learning tends to be monotonous and teacher-centered. The learning media applied has not been able to facilitate students to visualize each digestive organ and think critically when students need to prepare for the challenges of the 21st century. The era of revolution 5.0 with technological developments requires teachers to combine technology with learning in order to facilitate students to think critically, especially on the material of the human digestive system.

It's an important thing component in supporting learning is learning media. The existence of technology helps and facilitates the needs in learning activities (Wulandari et al., 2020). As a teacher, it should be an opportunity that needs to be utilized in developing learning (Araghieh et al., 2011). AR-based media is types of learning media that has begun to receive attention in this context. According to Al-Ansi et al. (2023), AR technology is starting to be utilized as teach and learn media at all levels of education. AR-based learning media has become the latest innovation in the world of education AR application use during learning improves students' perception of abstract objects to be real (Zhao et al., 2023). The use of AR stimulates intrinsic motivation and learning outcomes of students (Qumillaila et al., 2017). AR technology provides an interactive and engaging learning experience by enriching the learning process by bringing together the real and virtual worlds.

Essentially, application of varied media can interest and motivation for students in activities, AR is worth using in school learning as it has a high level on interactivity (Yi-Ming Kao & Ruan, 2022). In addition, AR is a technology that brings together the virtual with

the real world, has the aim of providing a message, real-time and interactive (Araghieh et al., 2011), and it provides space for imagination so that cognitive outcomes increase. This media facility learners to imagine so that the cognitive results increase. Based on this, it is concluded Augmented Reality (AR) media is able to unite the real world and the virtual world or visualize an object to make it look real and motivate interactive learning. In accordance with the problem that the use of conventional media has not facilitated students to think critically, Augmented Reality (AR) is a solution in delivering digestive system material (Yusa et al., 2023). Due to Augmented Reality (AR) is able to visualize the real form of the digestive system organs and interactive sentences in the media. The study tested effectiveness of AR based learning media to enhance critical thinking skills on IPAS material.

Test the effective of AR media to improve critical thinking skills by giving tests. This test was carried out by giving pretest and posttest questions, in order to find out the value before giving treatment to the pretest question and the posttest question was used to find out after the application of AR-based learning media. This test was carried out by design using experimental classes and control classes. The experimental class is given the application of AR-based learning media while the control class is not given the application of AR-based learning media. Experimental class with a sample of 56 students while in control class with a sample of 25 students.



Figure 6. First treatment

The experimental gives pretest questions and the implementation of Augmented Reality media in education activity in the material of the digestive system humans in the classroom was categorized into three treatments (Buchner & Kerres, 2023). The first treatment with the material of the digestive process in humans

with the provision of Augmented Reality-based media display and then presented an introductory video for students' apperception to be able to analyze and synthesize presented in Figure 6.

The second treatment was carried out with the material of the process and function of the digestive organs in humans by presenting a problem for children to solve the question and be ability to conclude a solution based on the results of his thinking presented in Figure 7.



Figure 7. Second treatment

The third treatment was carried out with coverage of digestive disorders in humans then students were asked to evaluate the results of questions from the professor and questions from evaluation questions in other tools presented in Figure 8.

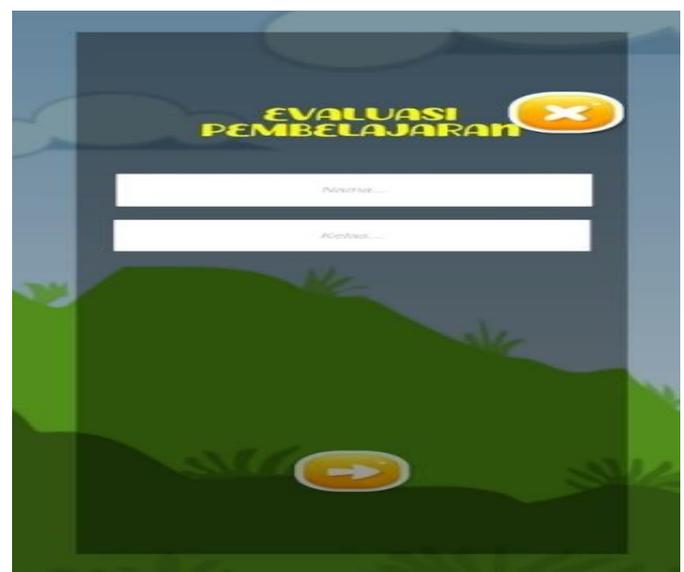


Figure 8. Third treatment

At the time of learning, students are actively involved when using Augmented Reality-based learning media, besides that student are motivated to learn it because students are able to operate themselves related to organs in the human digestive system. The application of media is inseparable from critical thinking skills (Zhang et al., 2023; Sun et al., 2023). Critical thinking skills are essential skills and function effectively in all aspects of life. The core cognitive skills of critical thinking are interpretation, analysis, evaluation, inference, explanation and self-regulation (Saputri et al., 2018), states five stages in critical thinking, namely the skills of analyzing, synthesizing, problem solving, concluding, and evaluating. This is in the study of critical thinking indicators used, namely analyzing, synthesizing, solving problems, concluding and evaluating which are contained in each treatment in the application of AR-based learning media.

The first treatment in the study of students is asked to analyze related to several kinds of digestive organs in humans that exist in the form of AR that can be operated individually (Hickey et al., 2023). After that, students are asked to analyze again related to the apperception video displayed regarding the food to be eaten through which digestive organs then students are asked to synthesize the results of using the media. The second treatment students are given questions in the conversation in order to be able to solve problems and be able to conclude from the results of the conversation related to the digestive process and its functions (Abdi et al., 2019). The third treatment, students conduct an evaluation with existing questions to find out the conclusions obtained from the learning outcomes that have been carried out and students are able to apply what should be applied so that there is no disturbance in the digestive system. After the treatment is done, the posttest questions are given. The average pretest was 58.92 and 58.80. The results of the experimental class after applying Augmented Reality-based learning media obtained a posttest value of 75.98 while the average value of the control class that did not apply Augmented Reality-based learning media obtained an average posttest value of 63.56 then pretest and posttest results study conducted an Independent Sample T-Test test to know if there is a significant increase in the critical thinking skills of students who use Augmented Reality-based learning media.

The results of the independent sample t-test test presented in table 6 obtained with a value of 0.000 with the provisions of the decision. Furthermore, the result of our test shows that the sig. value of 0.000 is smaller than 0.05 so it is synthesized that there is a sig. difference between the experimental class with the application of Augmented Reality-based learning media that provides an increase in the thinking skills of elementary school students (Zuniari et al., 2022). Furthermore, the

effectiveness test using N-Gain in Table 7. In the experimental class got a value of 56.52. It is concluded that the application of AR-based media improves the thinking skills of elementary school students, in particular grade V on the material IPAS. Another thing is also conveyed that the application of AR learning media is interpreted as effective in Geography subjects (Sungkur et al., 2016). Reinforced by the results of research (Nurlaily et al., 2021), which states that it is able to improve mastery of concepts by using Augmented Reality media. It is concluded that the application of AR-based learning media in learning is effective in improving critical thinking skills with the media category being quite effective in use.

Conclusion

Critical thinking skills results are done by giving a test. The results of the pretest average value of 58.92 and 58, 80. After applying AR-based learning media in the experimental class the average value of the posttest was 75.98 while the average value of the posttest in the control class without using Augmented Reality-based learning media was 63.56. The results of the Independent Sample T-Test test obtained a value of 0.00 with the provisions of the test decision if the significance value is less than 0.05 then there is a significant difference between the posttest of the experimental class and the control class. The test results get a significance value of 0.000 < 0.05 so it is synthesized that there is a significant difference between the experimental class with the application of AR-based learning media that provides an increase in the thinking skills of elementary school students and the N-Gain results get a value of 56.52 which is included in the category quite effective so it is synthesized that the application of AR-based media improves the thinking skills of elementary school students, especially grade V on the material IPAS.

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Author Contributions

Conceptualization, O. A. P., W., K. C. S., methodology, O. A. P.; validation, W and K. C. S.; formal analysis, O. A. P.; investigation, W and K. C. S.; formal analysis, O. A. P.; investigation, W and K. C. S.; resources, O. A. P and W.; data curation, K. C. S.: writing—original draft preparation, K. C. S and O. A. P.; writing—review and editing, W.: visualization, O. A. P and K. C. S.; supervision, W.; project administration,

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Conflicts of Interest

The authors declare no conflict of interest.

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