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Application Augmented Reality for Science Learning: Improving Critical Thinking Toward Elementary Student

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***Abstract*—** The study aimed to improve critical thinking in science education and describe student response in using Augmented Reality. It was Classroom Action Research carried out for three cycles. The subjects were teachers and students of the fifth grade at SDN 1 Kudu. The data were qualitative and quantitative. Data collection techniques were test and non-test data analysis include data reduction, data presentation, and drawing conclusions. The result indicated that average percentages critical thinking is improved. Based on the observed results cycle I= 71,17%, cycle II= 88,66%, and cycle III= 88,10%. Then, the improvement critical thinking by the written test were cycle I= 77,98%, cycle II= 85,90%, and cycle III= 86,92%. Students' response in using Augmented Reality was showing positive responses including feelings of pleasure, enthusiasm, and confidence during learning. The conclusion of this study was used Augmented Reality can improve critical thinking and positive responses in science education.

***Keywords*—** science learning, critical thinking, augmented reality, student response

I. INTRODUCTION

21st century skills have been adapted by the education system in Indonesia. In the 21st century, students are expected to have the skills to communicate, collaborate, think creatively, think critically, think innovatively, reason effectively, problem solve skills, and be able to use technology in life to face the challenges of the global world. (Erdem, 2019; Suryandari, et al., 2018). Learning that accommodates 21st century skills can be known as 21st century learning (Andrian and Rusman, 2019). One of the important 21st century skills for students to have is critical thinking skills. Critical thinking skills are skills that require high cognitive skills which include the ability to interpret, analyze, evaluate, conclude, and explain (Facione, 2015). Critical thinking skills in students make students able to express opinions well, solve problems, formulate hypotheses, and be able to understand complex things (Suryandari, 2020). Furthermore, critical thinking skills according to Saleh (2019) are the ability to answer critical questions, the ability to ask and answer questions promptly, and the desire to actively ask critical questions. Efforts to improve students' critical thinking skills can be carried out through the application of digital literacy during learning (Handayani, 2020).

Digital literacy is a component of 21st century life skills in the form of life skills with technology, information, and communication (Fitriyani and Nugroho, 2022). Digital literacy is a knowledge skill to use technology by accommodating knowledge literacy, internet literacy, web literacy, and digital literacy (Ayhan, 2016). Furthermore, Chan, Churchill & Chiu (2017) define digital literacy, namely the use of technology that involves the ability to understand, analyze, evaluate information received to find and use information as thoughts and disseminate this information through digital platforms. The implementation of digital literacy is considered important and effective in learning. This is because teachers can make learning more effective and students become more involved in learning, and make students have digital skills (Spires, Paul, & Kerkhoff, 2019).

Critical thinking skills have an important role in 21st-century learning, because in addition to mastering the material students will be able to apply the material in life. In science learning, students are expected to be able to understand, relate, analyze, evaluate, and interpret abstract science material (Vari and Bramastia, 2021). Therefore, science learning can improve students' critical thinking skills. Critical thinking skills in learning can be improved through innovative learning methods and media (Suryandari, et al., 2017). Therefore, to improve critical thinking skills in science learning, appropriate learning media is needed and can be used to understand, connect, analyze, evaluate, and interpret science material.

Based on interviews conducted by researchers with class V teachers at SDN 1 Kudu, Baki District, Sukoharjo

Regency, information was obtained that: (1) student involvement in learning was not optimal; (2) the effects of the Covid-19 pandemic are still being felt, namely children who are used to only seeing and then being forced to think, explain, and express opinions experience difficulties; (3) when learning science, children tend to be happy and active, but their mastery of concepts is still lacking; and (4) the level of students' critical thinking is still low, namely less than half of the whole class even though they have been given stimulation. Then, the teacher's problems are: (1) the learning media used have not varied; (2) teachers need a long time to cultivate students' critical thinking skills; and (3) learning is still centered on the teacher. Based on the results of interviews, students' critical thinking skills when learning science were still low, this was because the learning media used by the teacher did not accommodate students' critical thinking skills. Image and video media are used by the teacher to observe information, such as information on organ systems in humans. PPT media is used by the teacher to display information on learning topics. Then, simple teaching aids are used by the teacher to show the parts of the organ system in humans. Thus, the media used by the teacher when learning science does not accommodate students' critical thinking skills.

Based on the problems presented, a solution is needed, namely in the form of learning media that can improve students' critical thinking skills. The media that can be used is Augmented Reality. Augmented Reality is a learning media in the form of visuals that can change the virtual world into the real world, so that in science learning it is easier for students to find concepts (Herliandry, Kuswanto, and Hidayatulloh, 2020). Augmented Reality is a system that helps users to experience the real world through virtual overlays that make real objects and virtual objects in the same space and interact in real time (Bower, et al., 2014). Augmented Reality according to Nielsen, Brandt & Swensen (2016) is a system that adds or modifies the real world as a place where virtual objects are added. The characteristics of Augmented Reality are: (1) combining the real world and virtual world in the same environment and place; (2) interacting in real time; and (3) virtual objects in 3D form, so they will coexist with real world objects Augmented Reality (Kiryavoka, Angelova & Yordanova, 2018). Thus, the use of Augmented Reality in science learning can improve students' critical thinking skills. Improvement is evident in the cognitive domain of analyzing (C4) the use of Augmented Reality makes it easier for students to interpret things. In the cognitive domain of evaluating (C5) the use of Augmented Reality makes it easier for students to answer questions in the form of images and be able to solve problems in the form of conclusions. In the realm of creation (C6) the use of Augmented Reality helps students design simple experiments (Sylvia, Ramdhan, and Windyariani, 2021).

Based on the description that has been presented, the formulation of the problem in the research is: (1) can the use of Augmented Reality improve critical thinking skills in science learning for fifth grade students at SDN 1 Kudu in the 2022/2023 academic year?; (2) how is the response of class V students in using Augmented Reality when learning science?. The objectives of this study are: (1) to improve critical thinking skills in science learning for fifth grade students at SDN 1 Kudu in the 2022/2023 academic year; (2) to describe student responses in using Augmented Reality when learning science.

II. METHODOLOGY

The approach in this research is classroom action research, which means that research is carried out by observing learning activities in the form of actions in class (Arikunto, Suhardjono, and Supardi, 2014). Classroom Action Research is carried out through four stages, namely: (1) planning, (2) action, (3) observation, and (4) reflection (Parnawi, 2020). The type of Classroom Action Research used is the type of collaboration between the researcher and the class V teacher at SDN 1 Kudu as the executor of the action. The subjects in the study were teachers and class V students at SDN 1 Kudu for the 2022/2023 academic year, which consisted of 24 students.

The data used in this study are quantitative and qualitative data. Quantitative data is in the form of the results of a fifth grade student's written test at SDN 1 Kudu about the water cycle. While the qualitative data is in the form of interviews and observations of the use of Augmented Reality in learning science class V SDN 1 Kudu about the water cycle. Sources of data in this study were fifth grade students, fifth grade teachers, and documents. Data collection techniques used are 1) test techniques in the form of written tests with indicators of critical thinking questions, namely interpretation, analysis, and conclusions, 2) non-test techniques in the form of: a) observation of the use of Augmented Reality during learning and critical thinking skills in students, b) interviews about the use of Augmented Reality during learning and critical thinking skills in students, and c) study of documents from the results of the PAS analysis

of science subjects in class V SDN 1 Kudu. The data collection tools used were observation sheets, interview sheets, and written test sheets. The data analysis technique used is data reduction, data presentation, and drawing conclusions (Parnawi, 2020).

III. RESULT AND DISCUSSION

The Use of Augmented Reality to Improve Critical Thinking Skills in Learning Science

The use of Augmented Reality in research is used in the inquiry learning model. The steps of the inquiry learning model are: (1) orientation, the teacher gives problem orientation to students; (2) formulating the problem, the teacher guides formulating the problem; (3) formulating hypotheses, the teacher gives trigger questions to make it easier for students to formulate problem hypotheses; (4) collecting data, the teacher allows students to find the necessary information; (5) testing the hypothesis, the teacher guides students to prove the truth of the evidence that has been collected; (6) formulating conclusions, the teacher and students conclude the findings obtained to answer the problem formulation (Juniati and Widiana, 2017). The use of Augmented Reality is used in the orientation step and collecting data. In the orientation step, Augmented Reality is used to visualize 3D object orientation problems. Then, in the data collection step it is used to assist students in collecting the necessary data.

Critical thinking skills indicators include interpretation, analysis, evaluation, concluding, and explaining (Iqliya and Kustijono, 2019). The indicators of critical thinking skills used in this study are interpreting, analyzing, and concluding.

This research was conducted for three cycles with a research achievement indicator of at least 85%. This is because, the percentage of success of 80% -89% is included in the good category (Arifin, 2014). A comparison between cycles of observations of the critical thinking skills of fifth grade students in science learning can be seen in table 1.

Table 1. *Intercycle Comparison of Observation Results of Critical Thinking Skills of Class V Students in Science Learning*

Critical Thinking Skills Indicator	Cycle I	Cycle II	Cycle III
Interpretationon	72% Some students have difficulty explaining the interpretation of virtual 3D images with sentences.	87,16% Students can explain the results of interpretation according to virtual 3D objects that appear in the form of sentences.	89,33% Students explain the results of the interpretation according to the virtual 3D objects that appear in the form of sentences confidently.
Analysis	71,5% Students have difficulty connecting between the results of the interpretation of the identification of virtual 3D objects that appear with their knowledge.	86% Students can relate the results of identifying virtual 3D objects with their knowledge.	88,33 Students are able to relate the results of identifying virtual 3D objects with their knowledge and dare to express them confidently.
Conclude	70% Students make conclusions from general to specific. However, students have difficulty making sentences logically and the resulting conclusions do not collect all the information received.	85,66% Students can make conclusions from general to specific and the results of the conclusions have collected all the information received from virtual 3D objects. However, some students have not been able to use logical sentences.	86,66% Students are able to make conclusions from general to specific, collect all information received from virtual 3D objects that appear, and have made conclusions using logical sentences.
Rata-rata	**71,17%**	**88,66%**	**88,10%**

Based on information from table 1, the use of Augmented Reality in science learning can improve the critical thinking skills of fifth grade students. In the interpretation indicator students can explain the results of the interpretation by virtual 3D objects that appear in the form of sentences with confidence. The teacher at this stage always gives trigger questions that are easily understood by students and motivate students to be confident in expressing their thoughts. In the analysis indicator students can relate the results of identifying virtual 3D objects with their knowledge and dare to express themselves confidently. The teacher at this stage guides students to connect the results of the interpretation of the information received with the knowledge possessed by students. In the concluding indicator students can make conclusions from general to specific, collect all the information received from the virtual 3D objects that appear, and have made conclusions using logical sentences. The teacher at this stage guides students to make conclusions from general to specific and uses logical sentences. Therefore, the use of Augmented Reality in science learning can improve students' critical thinking skills. This is because students' mastery of science concepts is getting better with the use of Augmented Reality during learning.

According to Suryandari, Budi, & Kun (2017) mastery of science concepts can make students skilled in forming opinions, communicating in writing understood concepts, and confidently conveying new ideas based on understood concepts, so that students' critical thinking skills can increase. Therefore, it can be concluded that the use of Augmented Reality in science learning can improve students' critical thinking skills. This is because Augmented Reality can assist students in visualizing abstract objects into concrete in virtual 3D form in the real world, so it can encourage students to analyze virtual 3D objects that appear as a whole. In addition, the use of Augmented Reality requires high digital literacy skills, so as to improve students' critical thinking skills. This is in accordance with the expert opinion that Augmented Reality requires high digital literacy skills, so that students' critical thinking skills increase because they can analyze virtual 3D objects that appear according to the concept of science independently (Herliandry, et al., 2020).

Measurement of students' critical thinking skills was also carried out through written tests, namely the pretest and posttest which were carried out from cycle I to cycle III. Comparison between cycles of written test results of students' critical thinking skills can be seen in table 2 below.

Table 2. *Intercyclical Comparison of the Results of the Critical Thinking Skills Written Test for Class V Students in Science Learning*

Indicator	**Average**		
	Cycle I	Cycle II	Cycle III
Interpretation	81,41	86,02	87,08
Analysis	78,75	86,70	87,68
Conclude	73,79	85	86
Average	77,98	85,90	86,92

Based on table 2, information was obtained that the written test results in cycle I to cycle III had increased. In cycle I, the indicators for interpretation presented questions in the form of narration and pictures. In the questions in the form of narrative, students can correctly mention and give reasons for the benefits of water for life. Meanwhile, in the questions in the form of pictures students were able to correctly identify the benefits of water for life according to the pictures. In the analysis indicators, questions are presented in the form of pictures and tables. In the problem in the form of pictures, students are ablecanly describe and analyze pictures of the process of an event occurring. Meanwhile, in the questions in the form of tables students were able to analyze the elements of the water cycle and their explanations correctly. In the concluding indicator, questions are presented in narrative form, students can conclude problems that are in accordance with the narrative correctly.

In cycle II the interpretation indicators were presented in the form of pictures, students were able to identify the pictures correctly. In the analysis indicators, questions are presented in the form of pictures accompanied by narration. Students can analyze the processes that occur according to the picture correctly. In the concluding indicator, questions are presented in the form of statements and pictures, and pictures are presented for conclusions. In questions in the form of statements and responses students are ablecane and give reasons why they agree or disagree according to the statements and responses correctly. In the problem in the form of pictures to conclude, students are able to conclude logically about the water cycle correctly.

In cycle III the interpretation indicators are presented in the form of pictures, students are able to identify solutions that match the pictures and correctly identify

the elements of the water cycle. In the analysis indicators, questions are presented in the form of narration and pictures. In narrative questions students are able to analyze a suitable plan to solve the problem according to the narrative correctly. Then, in the questions in the form of pictures students are able to mention and analyze the reasons for the events in the picture occurring. In the concluding indicator, questions are presented in the form of narrative. Students are able to enter all the information received from the narrative in sequence and use logical sentences. Based on the information that has been described, it can be concluded that the use of Augmented Reality in science learning can improve students' critical thinking skills written test results. This is in accordance with the research of Sylvia, Ramdhan, and Widyarini (2021) which shows that the acquisition of scores for indicators of critical thinking skills at the pretest and posttest has increased. The interpreting indicator experienced an increase in score because students were able to interpret questions about the working mechanism of the sensory organs in humans, the analyzing indicator students were able to analyze questions by linking lifestyles with responses to sensory organs, and an increase also occurred in the concluding indicator, namely students were able to conclude simple experimental mechanisms sense organs in humans.

Responses of Class V Students in the Use of Augmented Reality in Science Learning

The use of Augmented Reality in science learning gave rise to a positive response in fifth grade students at SDN 1 Kudu. Students' positive responses are feelings of pleasure when learning, enthusiasm when learning, and self-confidence when learning. Student responses when using Augmented Reality in science learning can be seen in Figure 1 below.

Figure 1. *Student Responses in the Use of Augmented Reality during Science Learning*

The comparison between student response cycles in the use of Augmented Reality when learning science can be seen in table 3 below.

Table 3. *Comparison between Student Response Cycles in the Use of Augmented Reality Media during Learning*

Indicator	Cycle I	Cycle II	Cycle III
Students enjoy learning.	Average= 91,66% Students are happy when using AR media when learning science. Some students feel sad because the devices they have don't support them.	Average = 93,22% Students are happy because all student devices can be used.	Average = 94,72% Students are accustomed to operating Augmented Reality.
Students are enthusiastic during learning.	Average = 85,93% Some students are enthusiastic and active during learning because AR media can bring up interesting images during learning.	Average = 87,5% Some students are enthusiastic and active during learning because the teacher always provides motivation.	Average = 88,54% Students are enthusiastic and active during learning because the virtual 3D objects that appear are easy to understand.
Students are confident when learning.	Average = 82, 29% Some students are not used to operating AR media, so students do not dare to express their opinions.	Average = 85,41% Students are getting used to using AR media and students are interested in the different virtual 3D objects that appear and some students have the courage to express their opinions with confidence.	Average = 86,97% Students have the courage to express their opinions and the results of their identification with confidence.

Based on table 3, information is obtained that the use of Augmented Reality makes learning fun and enjoyable. Then, the enthusiasm of students during learning increased because students did not only listen to the teacher's explanation during learning. However, students are excited when answering questions from the teacher because the material presented by the teacher is interesting, and students are active during learning, so that students' understanding of the material increases. This is in accordance with the research of Jannah and Oktaviani (2022) that with high student enthusiasm, the teacher's explanations will be well heard by students and students' understanding of the material will increase. After that, students feel more confident because when learning uses Augmented Reality because students are more confident about the opinions they convey regarding virtual 3D objects that appear and dare to express their opinions in class.

IV. CONCLUSION

Based on the results and discussion, the conclusions from this classroom action research are as follows: (1) the use of Augmented Reality in science learning applied in the inquiry learning model can improve students' critical thinking skills as shown in the results of observations and students' written tests. The observation results showed an increase in the indicators of critical thinking skills for interpretation, analysis, and conclusions, namely in the first cycle of 71.17%, the second cycle of 88.66%, and the third cycle of 88.10%. Then, the increase in critical thinking skills on written test results, namely in cycle I was 77.98%, cycle II was 85.90%, and cycle III was 86.92%. (2) the use of Augmented Reality is able to generate positive responses to students, namely in the form of feelings of pleasure during learning, enthusiasm during learning, and confidence during learning. Researchers hope that the use of Augmented Reality during learning can be used as a reference for teachers to determine the right media to improve students' critical thinking skills. In addition, researchers hope that there will be virtual 3D object innovations that are applied to other subjects to be used in further research, so that they can become a teacher's reference when learning.

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