



Development of Augmented Reality Integrated Teaching Materials to Improve the Critical Thinking Ability of Gen-Z Students at Primary School Level

Dian Sunarti; Darmiany; Asrin; I Wayan Karta; A. Hari Witono

Master of Elementary Education, Faculty of Teacher Training and Education, Mataram University, Indonesia

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Abstract

This research aims to learn how to develop augmented reality-integrated teaching materials. Apart from that, to determine the effect of using augmented reality-integrated teaching materials in improving students' critical thinking abilities. The research approach used is a research and development approach. The population in this study were all students of the fifth level of Ampenan 5th State Elementary School for the 2023/2024 academic year. The research design used in this research is the ADDIE model design (Analysis, Design, Development, Implementation, and Evaluation). The data collection technique was carried out using a questionnaire. After the data is collected, data analysis is carried out to achieve the research objectives. The results of data analysis show that the validation score for teaching material products is at 95% from media experts, and 95% from material experts. Based on this score, it can be concluded that Augmented Reality integrated teaching materials have high validity. Practitioner assessments of teaching materials show results in the very good category. The results of the effectiveness test show that there is a significant difference between the pretest and post-test results, which means that it shows that there is an influence of the application of Augmented Reality integrated teaching materials on the critical thinking abilities of grade 5th students on digestive organs, science, and science content at Ampenan 5th State Elementary School.

Keywords: *Teaching Materials; Augmented Reality-Integrated; Critical Thinking Skills; Gen-Z*

Introduction

Education in Indonesia is a vital aspect of nation-building. Even though it has improved over time, there are still several challenges that need to be overcome. The quality of education in Indonesia can be measured from various indicators, including facilities and infrastructure, educator qualifications, and the learning methods used. As a developing country, Indonesia needs to continue to strive to improve the quality of education so that it can compete globally.

In the Global Education Monitoring (GEM) Report 2023 conducted by UNESCO, data shows that education in Indonesia is ranked 67th in the realm of education among 203 countries throughout the world (Global Education Monitoring Report Team, 2023). One of the problems that arises is due to students' lack of reasoning ability. Based on the results of the 2018 PISA test, the reasoning ability of Indonesian

students is still classified as very low, namely ranking 7th from the bottom out of 78 countries. The ability to reason is one of the competency demands that students must have in the 21st century.

21st-century learning aims to create students who have 21st-century skills consisting of the 4Cs (communication, collaboration, critical thinking, and creativity). These 4C skills were first introduced by the US-based Partnership for 21st Century Skills (P21) which consist of communication, collaboration, critical thinking, and creativity (Prihadi, 2018). One of the 21st-century skills that is expected to be achieved in the demands of an independent curriculum is the ability to think critically. Critical thinking skills are very important in forming a generation that can analyze information, make decisions, and solve problems wisely. Unfortunately, the majority of students in Indonesia still experience obstacles in developing critical thinking skills, which should be the foundation for their success in the future (Nasihah, Supeno, & Lesmono, 2020).

According to Lestari(2021) currently, students' critical thinking abilities are in the very poor category. The results of other research conducted by Pertiwi (2018) found that students' critical thinking abilities were still low, as seen from the number of students who fulfilled each aspect of critical thinking abilities below 50%. In research conducted by Salsabilla, Darmiany, & Setiawan (2022) in one of the elementary schools on Lombok Island, it was found that students' critical thinking abilities were still in the less critical category with a percentage of 44%. The data collected by researchers in the field was not much different from the test results on students' critical thinking abilities at SDN 45 Ampenan, Mataram City in the science and sciences subject, it was found that the average score for students' critical thinking abilities was 61 in the low category (Appendix).

The lack of critical thinking skills of students in Indonesia is caused by several factors. First, many teachers have not paid serious attention to the three main components of learning. The main components are teachers, students, and teaching materials. In daily practice, teachers only focus on developing learning media, learning strategies, learning models, and other supporting components. The teacher's main focus should be creating these three main components. The reality in the field is that many teachers only use available teaching materials without innovating and developing them further according to students' needs and characteristics. This is supported by data collected by researchers through distributing questionnaires via Google Form which were filled in by 52 teachers in several regions in Indonesia. The results found that only 53.8% of teachers knew the three main components of learning, the rest varied, and some considered media and strategies to be the main components of learning. Apart from that, 82.7% of teachers are accustomed to using available printed books as teaching materials in class, and the remaining 17.3% of teachers develop their teaching materials (Appendix). The development of teaching materials needs to be carried out by teachers as a form of manifestation of teacher professional competence. Research conducted by Aryzona, EF, Asrin, A., & Syazali, M. (2023) in one of the elementary schools in the city of Mataram shows that teachers have low professional competence in implementing the independent curriculum.

The second factor, namely the characteristics of current students. Students today are known as Gen Z, who have learning characteristics, namely they don't like to spend too long listening to teacher lectures, Gen Z prefers to explore and is more likely to play an active role in learning rather than being passive by just listening, apart from that, Gen Z likes to interact with new media (new media) such as smartphones, laptops, computers, and other technological tools (Haryana, et al, 2024). Gen Z has the characteristic of self-directed learning where they can diagnose their own learning needs, this is what teachers need to analyze students' learning needs and styles (Haryana, et al (2024). Apart from that, Gen Z has a short attention span (short attention span) where they are only able to concentrate for around 8 seconds (Glum, 2015). When learning only uses conventional teaching materials, it will have a direct impact on students, both in terms of learning outcomes, students' way of thinking, and attitudes. They tend to feel bored and less motivated to learn, which can hinder the development of their critical thinking skills. This diversity also creates challenges for teachers in maintaining student interest in the learning

process. For this reason, teachers need to innovate in learning by integrating technology to create fun and meaningful learning for students. As stated by Salsabilla, Darmiany, & Setiawan (2022) teachers should be more creative and innovative in delivering learning material and teachers need to understand the characteristics of each student. By understanding student characteristics, teachers can adjust teaching skills to increase student motivation and thinking abilities. Similar research results were also revealed by Ambarita (2020) who found that several students experience because of boredom in learning, so it is necessary to develop teaching materials.

Low critical thinking skills also occur in several lessons, including in science or natural and social sciences subjects. IPAS has a dynamic characteristic that requires teachers to update their knowledge to adapt to changes in existing knowledge. Not only that, certain science materials have abstract characteristics that make students unable to meet the demands of an independent curriculum that expects students to be able to think critically. Students' inability to think critically is characterized by the lack of students asking questions and answering questions asked by the teacher in class. Science material that is not well understood by students includes the digestive system where the average score for students' thinking abilities in this material is 61 and is still considered low. Students experience problems in understanding the human digestive system because they have never directly seen the digestive organs in the human body and the limited learning media available at school. Abstract material becomes a challenge in the learning process, creating obstacles in understanding and developing students' critical thinking skills.

The development of teaching materials needs to adapt to the character and needs of Gen Z students as digital natives. Pustikayasa (2023) mentions the characteristics of Gen Z students as one of the factors influencing the evolution of current educational aids. Besides that Sayyidina Ali RA once stated a wise sentence that is popular among Muslims, "Educate children according to their time" (Sayyidina in Rodiah, 2019). Haryana, et al (2024) also added that the competencies that teachers must have to teach in the 21st century are digital skills where teachers must understand the technology and be ready to learn and explore innovative and creative ways of using technology to teach. Therefore, as a solution to the problems above, it is hoped that the development of technology-integrated teaching materials can be an innovative step in improving students' critical thinking skills in Indonesia. This research focuses on developing integrated IPAS teaching materials with Augmented Reality technology.

The teaching materials developed are in the form of learning modules that can be produced in print and electronic form. So, this research aims to create a product in the form of a learning module that is integrated with Augmented Reality technology. It cannot be denied that technology is a supporting medium in providing education in the digital era today (Hanafiah, 2022). Not only that, the learning modules that are developed certainly follow the demands of the applicable curriculum, namely that learning activities are directed at project-based learning. So, at the end of the learning activity, it is hoped that students can produce products that can also increase their understanding of digestive material. This is also based on considerations of Piaget's learning theory. Elementary students are still in the concrete operational phase where elementary students can easily understand based on concrete objects (Novita et al 2023). Not only is it integrated with augmented reality technology, but the module that will be developed in this research is also planned to be integrated with interactive worksheets based on the live worksheet application.

The integration of augmented reality technology can provide a more interactive, immersive learning experience and motivate students to actively participate in the learning process. In research conducted by Sari et al (2023), it was found that a three-dimensional building model based on Augmented Reality (AR) could provide a more interesting and interactive learning experience than conventional methods, which are often considered monotonous by elementary school students. In line with this, Nordin, et al (2022) developed an AR-based learning application and found that 92.6% of respondents stated that the use of AR in learning made learning more interesting. Research conducted by Setyono, et al

(2023) revealed that the development of a car audio system learning module integrated with augmented reality has a positive effect on student learning outcomes.

For this reason, this research has the title “Development of Augmented Reality Integrated Teaching Materials to Improve Students' Critical Thinking Ability on Digestive Materials subjects Elementary School Science”. Research is hoped that it can provide innovative solutions that can improve students' critical thinking skills, overcome the problem of monotonous sources of teaching materials, limited learning media, and learning that tends to be teacher-centered, and of course, can adapt to the characteristics of Gen Z students. This will have a positive impact on development. education that is more effective and relevant to the demands of the times.

Literature Review

Teaching Materials

Carrying out learning (teaching) is defined as the process of creating and maintaining an effective learning environment, while materials are defined as materials that support the implementation of the learning process both in the classroom and outside the classroom (Djauhar, 2008). The Ministry of National Education (2008) explains that teaching materials are information, tools, and texts that teachers/instructors use to plan and implement in teaching and learning activities.

Sungkono (Sugiarni., 2022) states that teaching materials are a set of materials that contain learning material or content to achieve learning objectives. Widodo and Jasmadi (Kelana & Pratama 2019) argue that teaching materials are a set of learning tools that contain materials, methods, limitations, and ways of evaluating. Apart from that, teaching materials need to be designed systematically and attractively to achieve the expected goals.

Good teaching materials must be appropriate to the learning objectives. This means that teaching materials must be able to present relevant material by the competencies or knowledge that students want to achieve. Apart from that, effective teaching materials must be able to encourage student involvement so that learning becomes two-way and student-centered (student center) Widodo and Jasmadi in (Lestari. 2013),

Aisyah (in Sugiarni, 2022) explains the three main functions of teaching materials in terms of the implementation of the learning process, namely as follows:

- 1) Teaching materials are a benchmark for educators that leads to the learning process as well as substance in competencies that should be applied to students.
- 2) Teaching materials are a benchmark for students that leads to the learning process as well as substance in the competencies that students should learn and understand.
- 3) Teaching materials are a tool for evaluating the achievement of learning outcomes following the indicators and basic competencies that educators want to achieve. Basic competencies and indicators have been arranged in the formulated subject syllabus.

Augmented Reality (AR)

Augmented Reality is a technique that combines two-dimensional and three-dimensional virtual objects into a real three-dimensional sphere and then projects these virtual objects in real time (Pamoedji, et al., 2017). Ismayani (2020) explained simply that Augmented Reality (AR) is an integration between the virtual world and the real world. Andriyadi (2011) more fully explains the meaning of Augmented Reality (AR) which refers to technology that integrates two or three-dimensional virtual objects into the real world and displays these objects in real time in a physical environment.

According to Azuma et al. (2001), AR technology has several main characteristics, namely:

- 1) Combines the real and virtual worlds in a natural-looking environment.
- 2) Interactive in real time.
- 3) Displays content in three dimensions (3D).

There are two types of imaging methods in Augmented Reality (AR) technology as explained by Lyu (2012), namely:

1) Augmented Reality Without Markers (Markerless Augmented Reality)

One method that is currently being developed in Augmented Reality technology is the Markerless Augmented Reality method. With this method, users no longer need to use markers to display digital elements. Examples of markerless AR include face tracking, three-dimensional object tracking, and motion tracking. Apart from that, there is also AR which uses GPS or digital compass features. GPS-based tracking techniques utilize the GPS and compass features in smartphones, which allows the application to display the desired direction or location in real-time.

2. Marker Based Tracking

One method that has been known in the world of Augmented Reality (AR) technology for quite a long time is the Marker-Based Tracking method. In this AR system, markers are used in the form of images that can be analyzed to form a reality. These image markers are known as "markers." The main characteristic of marker-based AR is the use of camera features on the device to analyze detected markers to display virtual objects, such as videos. Users can move the device to view virtual objects from a variety of different angles, allowing them to view virtual objects from multiple perspectives.

Critical Thinking Ability

Sihotang (2019) defines critical thinking as an active and careful consideration regarding accepted beliefs or knowledge. In the same source Edward Glaser developed this opinion by adding that critical thinking emphasizes the ability to use methods in solving problems. Robert Ennis further described critical thinking as the ability to think reflectively and the ability to make decisions.

Meanwhile, Rakhmasari (2010) quotes indicators of critical thinking abilities according to Ennis, which consists of twelve components, including:

- 1) Formulate the problem;
- 2) Analyze arguments;
- 3) Ask and answer questions;
- 4) Assessing the credibility of information sources;
- 5) Make observations and assess observation results reports;
- 6) Make deductions and evaluate deductions;
- 7) Making inductions and assessing inductions;
- 8) Evaluate;
- 9) Defining and assessing definitions;
- 10) Identify assumptions;
- 11) Decide and implement; And
- 12) Interact with other people.

Generation Z

Generation Z or commonly called Gen Z is the generation born in 1997-2012 (Kharimah in Karina, M. et al, 2021). Generation Z has several names, including iGeneration, Gen Net, and Digital Natives because this generation was born during a period of technological transition, Gen Z was born amidst the use of the internet and sophisticated technology (Rastati in Karina, M. et al., 2021). It is not surprising that this generation has intelligence in utilizing science and technology so that they are known as "iGeneration" or "Digital Natives" because they grew up in an era of increasingly advanced digital technology (Sudaryanto, et al. 2024. p. 10).

Currently Gen Z middle are at all levels of education. This means that teachers must consider learning by the characteristics of Gen Z. Quoted in the book Sudaryanto, et al (2024) categorize Gen Z as being born in 1997-2012 with the current age being 11-26 years. If you look at this data, in elementary schools students who are classified as Generation Z are students in grades 4, 5, 6, or high grade students. Meanwhile, students under grade 4 fall into the Alpha gene category.

Generation Z has the characteristics of liking instant things and depending on technology. Generation Z does everything using technology, from shopping to playing games and studying, Generation Z even has a digital wallet which makes it easy for them to make transactions simply via smartphone.

Quoted by Haryana, et al (2024, p. 154) Generation Z has several characteristics, including:

- 1) Generation Z likes freedom in learning (self-directed learning) starting from diagnosing learning needs, determining learning goals,
- 2) Generation Z likes to learn new, practical things so it is easy to shift their focus on learning even though they have sufficient time to study them.
- 3) Feel comfortable in an environment connected to the internet because it fulfills the desire to surf, be creative, collaborate, and help share information as a form of participation.
- 4) Generation Z prefers to communicate with images, icons, and symbols rather than text. Generation Z doesn't like listening to teachers' lectures for long, so they are more interested in exploring than listening to the teacher's explanations.
- 5) Having a short attention span (short attention span) or in other words, it is difficult to concentrate for long periods. Generation Z is used to being in contact with high technology with fast accessibility, for example, smartphones. The human attention span is getting shorter, around 8 seconds (Glum, 2015).

Framework of Thinking

In the learning process, three main components are conditions for the implementation of the teaching and learning process. The three main components are teachers, students, and teaching materials. If wrong one of these main components is absent, the learning process cannot occur. Meanwhile, other components such as media, strategies, evaluation, and learning facilities are additional components in the learning process. However, teachers often only focus on learning media, the learning strategies that will be used. Meanwhile, the main component, namely identifying the characteristics of teaching materials, is very rarely carried out by teachers. The characteristics of teaching materials are one of the considerations for choosing learning strategies and media. As a result, what often happens in the field is that teachers only use monotonous teaching materials, such as printed books and student activity sheets.

In supporting the achievement of optimal learning objectives, teaching materials are one of the things component. The main aspects of the learning process need special attention because the available teaching materials are not yet appropriate to the student's circumstances. One way that teachers can do this is to develop their teaching materials that suit the characteristics of students and the subject matter.

Natural and Social Sciences (IPAS) is one of the compulsory subjects in elementary schoolsholdimportant role. The importance of science as a compulsory subject in elementary school cannot be ignored. IPAS plays a central role in the educational development of children at the primary level. This is because this subject combines aspects of natural science and social science which provide a basic understanding of the world around and society. IPAS has characteristics, including being abstract, which makes it not uncommon for certain materials student less able to understand the lesson.

Augmented reality (AR) is a combination of virtual-world objects and real-world objects in real time. Using Augmented Reality (AR) it is hoped that the learning process will be more interesting and students' critical thinking skills will be developed. The following is the framework of thinking developed in this research.

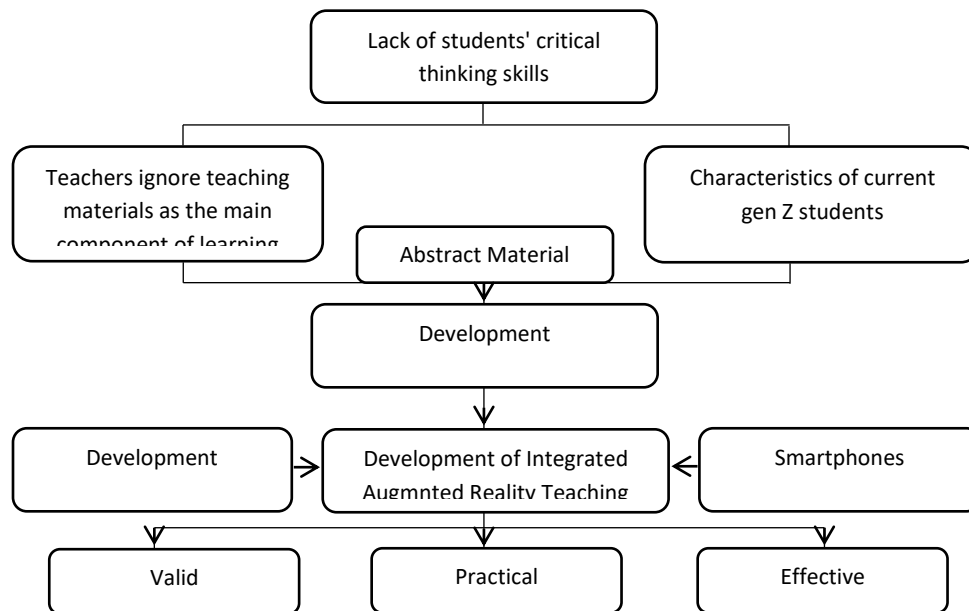


Figure 1. Framework for Thinking

Research Methods

The research approach used is a research and development approach. Richey and Kelin state that design and development research is a systematic study of how to create, develop/produce, and evaluate a design to obtain empirical data. This data can be used as a basis for creating products, tools, and models in learning or non-learning (Sugiyono, 2022). The population in this study were all students of SDN 45 Ampenan class V for the 2023/2024 academic year. The research design used in this research is the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model design (Anam, 2023:78). The data collection technique was carried out using a questionnaire. After the data is collected, data analysis is carried out to achieve the research objectives.

Data analysis in this research uses validity analysis, practicality analysis, and effectiveness analysis.

1) Data Analysis of Validity of Science Teaching Materials integrated with Augmented Reality

There are two data on the validity of teaching materials, namely the validity of Augmented Reality media and the validity of IPAS teaching materials. Data on the validity of integrated augmented reality science and technology teaching materials evaluated by validators was obtained through validity

testing by applying the Gregory test. Susetyo (2015) states that a device is declared valid if the content price is above 0.5.

2) Data Analysis on the Practicality of Integrated Augmented Reality Teaching Materials

After collecting data using a questionnaire that measures student responses and teacher responses to the teaching material products being developed, the collected data is then analyzed quantitatively using percentage analysis. Student response analysis activities involve three types of data, namely student response questionnaires, teacher response questionnaires, and percentage calculations. To calculate the percentage of practicality of integrated Augmented Reality teaching materials, it can be analyzed by comparing the scores of the sources (Σ) with Arifin's ideal total score (N) (in Endang, 2016).

3) Data Analysis of the Effectiveness of Augmented Reality Integrated Teaching Materials to Improve Students' Critical Thinking Abilities

To analyze the effectiveness of augmented reality-integrated teaching materials in improving students' critical thinking abilities was done using comparative analysis, namely comparing students' critical thinking abilities before and after the use of teaching materials. To obtain comparative data, this was done through an experimental method with a One Group Pretest-Posttest Design, namely a related/paired sample t-test. To facilitate data analysis in this research, we used the help of the Statistical Program for Social Science (SPSS) version 25 with the paired sample test formula.

Result

This research and development produced a product consisting of interactive teaching materials using Augmented Reality Technology with the help of the Assembly Edu Application on the Human Digestive System material for grade 5 SD/MI. The process of developing this teaching material follows the ADDIE model which consists of the following steps: analysis, design, development, implementation, and evaluation.

a. Stage I – Analysis

1) Performance Analysis

Data performance analysis is obtained through interviews with teachers and interviews with students at SDN 45 Ampenan. In interviews with teachers and students, the results showed that in science learning, especially the digestive system material, many difficulties had been encountered due to the media not being available and the material being abstract. Teachers only depend on textbooks, worksheets, and learning videos on YouTube. As a result, student involvement becomes less and learning tends to be teacher-centered.

Furthermore, interviews were conducted with 10 grade 5 students at SDN 45 Ampenan. The results showed that some of the science and science learning material was considered difficult because it was abstract, such as the Digestive System material, so media or other supporting teaching materials were needed to make it easier for students to understand the material.

2) Analysis of Student Needs

The second stage of analysis is an analysis of student characteristics. At this stage, the aspects analyzed are the student's condition, including initial knowledge, general interests, and talents, learning style, and language skills. Data from the analysis of student characteristics was obtained from cognitive and non-cognitive diagnostic tests.

The results show that students' initial knowledge is still far below the KKM. From the aspect of interest and talent, students show an interest in using media in the form of audio, visual, audio-visual, and direct practice. In terms of learning style, most students like audio, visual, and direct practice, while the students' language skills are 100% of students speak fluent Indonesian. Apart from that, students' interests and talents are different for female and male students. Female students like things that can develop knowledge and skills, such as reading and cooking. Meanwhile, male students generally like physical play activities, such as ball. However, female and male students have something in common, namely they like surfing social media.

3) Competency Analysis

Competency analysis aims to determine the learning capabilities that students want to achieve after using integrated Augmented Reality teaching materials developed, including knowledge, attitudes, and skills. Students carry out simulations using simple pictures/charts/tools/media about the human body organ system (digestive system) which is related to how to properly maintain the health of the body's organs.

b. Stage II – Design

The second stage of development aims to ensure that the teaching materials developed can attract students' interest so that they feel happy and enthusiastic about the learning materials. This stage involves several important steps such as preparing learning materials, selecting appropriate media, and initial design to ensure suitability to students' needs.

Students carry out simulations using simple pictures/charts/tools/media about the human body organ system (digestive system) which is related to how to properly maintain the health of the body's organs.

1) Media Selection

The teaching materials developed are integrated with Augmented Reality media using the Assemblr Edu application. Media selection is adjusted to the needs and characteristics of students. Apart from that, the preparation of the module also utilizes the Canva application and live worksheet application to create interactive LKPD. The teaching materials were all designed by the researchers themselves without help from other parties.

2) Initial Design

Initial design was to prepare the product before it was tested by preparing designs for teaching materials and instruments.

3) Instrument Preparation

The instruments designed at this stage include needs analysis questionnaire instruments, material expert validation instruments, media expert instruments, user validation instruments, and student response test instruments.

c. Stage III – Redevelopment

In this development stage, several things are carried out, including the following:

1) Product Validation

a. Validity Augmented Reality Materials

The assessment of integrated Augmented Reality teaching materials from material experts aims to determine the validity of the material based on the digestive system material. The material expert assessment was carried out by 2 lecturers at the Faculty of Teacher Training and Education, Mataram University, namely Dr. Gunawan, M.Pd. and Dr. Asrin, M.Pd. Validation result data from two material experts is calculated using the formula Gregory test to obtain results that all aspects of teaching materials assessed by two experts have very high validity. So that the teaching materials used from the material aspect are suitable for use.

b. Validity Augmented Reality Media

The assessment of Augmented Reality-based interactive modules for media experts aims to determine the validity of Augmented Reality media which is integrated into teaching materials. The results show that the level of validity of the Augmented Reality media presented is very high. So that the Augmented Reality media in this teaching material is suitable for use.

c. Validation of the Critical Thinking Ability Instrument

The assessment of the critical thinking ability test instrument is carried out to determine the validity of the test questions used to measure students' critical thinking abilities. Through the Pearson Correlation test in the SPSS 25 application, it can be seen that 22 questions are declared valid and there are 8 questions that are declared invalid. So the questions used to measure students' critical thinking abilities were 22 questions which were declared valid.

Next, the reliability test used Cronbach's Alpha analysis on the SPSS 25 application. From the output data results were obtained Cronbach's Alpha value is 0.948. The basis for decision-making, if the alpha coefficient value is > 0.60 , it is said to be reliable. These results show that $0.948 > 0.60$ so the instrument can be reliable and included in the satisfactory category so that the instrument can be used to collect data during research.

d. Validation of Treatment Instruments

The assessment of the treatment instrument in the form of a Teaching Module was carried out by two experts from two educational practitioners, namely Uswatun Hasanah teacher from SDN 26 Mataram and Ifit Ayudiani teachers from SDN 37 Mataram. This assessment aims to determine the validity of the teaching module media that will be used. Results The validation of the teaching module as a treatment instrument obtained 100% results with a very high validation category. Therefore, the teaching module design developed can be used as a treatment instrument at the implementation stage.

2) Limited Trial

This stage is a continuation of the development stage. At this stage, the design of teaching materials that have been developed is then tested on a small scale. Small-scale trials were carried out to find out the convenience use of integrated Augmented Reality teaching materials developed. Data obtained from teacher respondents and student respondents was at a percentage of 91.9% and the practicality category was very good. Furthermore, teaching materials can be tested on a large scale.

d. Stage IV – Implementation

The implementation stage is carried out to test the effectiveness and attractiveness of the teaching materials developed. In this implementation phase, only 22 grade 5 students at SDN 45 Ampenan were used as users. From the results of implementation in class, it was found that the student's average score before treatment was 63.32 and the score after being given treatment was 81.14. while the attractiveness percentage is 93% and is in the very good category.

Stage V - Evaluation

The evaluation phase is the final stage of the ADDIE model. The evaluation referred to at this stage is formative and summative evaluation. Formative evaluation is used at the end of each meeting to improve products and train students to think critically, while summative evaluation is carried out at the end of the unit to see the effectiveness of using integrated Augmented Reality teaching materials on students' critical thinking abilities. Hypothesis analysis in this research uses a paired sample t-test with the help of SPSS 25. The results of the paired sample t-test is below.

Table 1. Paired Samples Test

		Paired Differences				t	df	Sig. (2-tailed)	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower				Upper
Pair 1	Before Treatment - After Treatment	-17.818	8.033	1.713	-21.380	-14.256	-10.403	21	0.000

From the output results of the paired sample T-test using SPSS version 25 above, the sig value is known. (2-tailed) of 0.000. Based on decision making in the paired sample t-test if the sig value. (2-tailed) < 0.05 then H_0 is rejected and H_a is accepted. In the data above, the sig value. (2-tailed) of $0.000 < 0.05$ so it can be concluded that there is a significant difference between the results of the pretest and post-test, which means that it shows that there is an influence of the application of Augmented Reality integrated teaching materials on the critical thinking abilities of class 5 students on the subject of digestive organs, the content of Science and Technology in Ampenan 45th State Elementary School. Apart from that, the significance data is also supported by the average data on the pretest and posttest results in the SPSS output as follows.

Table 2. Difference Between the Average Value

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Before Treatment	63.32	22	12,564	2,679
	After Treatment	81.14	22	9,858	2,102

Looking at the descriptive statistics, it is clear that there is a difference between the average value before treatment, namely 63.32 (pretest), and the value after being given treatment, namely 81.14 (posttest) using teaching materials that have been developed. From this data, it can be seen that after implementing integrated Augmented Reality teaching materials, students' critical thinking abilities on digestive organ material increased.

Because the average value of student learning outcomes on the pretest is $63.32 < \text{post-test } 81.14$, then it can be interpreted descriptively as there is a difference in the average learning outcomes between before and after treatment using integrated Augmented Reality teaching materials in students' critical thinking abilities on digestive organ material. In simple terms, it can be seen that there was an increase in students' critical thinking abilities of 17.91.

Discussion

Product Development

Hasil data needs analysis session it was found that students from the aspect of interest and talent, students show an interest in using media in the form of audio, visual, audio-visual, and direct practice. From the learning style, most students like audio, visual, and direct practice learning, while the students' language skills are 100% of students speak fluent Indonesian. This is a consideration in designing teaching materials as stated by Nindiasari et al. (2016) who stated that learning styles are a manifestation of individual diversity which teachers must pay attention to in designing learning. This is in line with opinion Septiani and Afiani (2020) which states that student characteristics and student personality are the basis for learning.

The third analysis activity is competency analysis contained in learning outcomes. The purpose of competency analysis is to serve as a guide for teachers in compiling teaching materials to achieve the competencies specified in the curriculum. The development of teaching materials is based on Phase C learning outcomes in the independent curriculum. Magdalena et al (2020) stated that teaching materials also need to be designed according to the characteristics of the material.

The next a is data at the design stage with activities carried out including learning materials, designing media, and making initial designs of teaching materials. At the stage of compiling learning material, the digestive system material is based on Learning Outcomes: Students carry out simulations using simple pictures/charts/tools/media about the human body organ system (digestive system) which is related to how to properly maintain the health of their body organs. The material content consists of the function of food for the body, digestive organs, digestive disorders, and maintaining digestive organs. This material is used in developing integrated Augmented Reality teaching materials which are integrated with material supporting media.

The second planning stage is the selection of teaching materials and supporting media. The teaching materials selected and developed by researchers are integrated with Augmented Reality media. In making teaching materials, the Canva for Edu application is used to design modules. The Canva for Edu application was chosen because it has pro features and educational elements that support designing teaching materials for learning. Apart from that, the Canva for Edu application is easy to use but has disadvantages, including not being able to italicize writing if it is in the same text box, so researchers have difficulty writing italicized foreign terms.

Meanwhile, to design Augmented Reality media, the Assemblr Edu application is used because this application is quite easy to use and the 3D elements provided are very realistic. However, the drawback is that the elements in the Assembly Edu application are not complete, so certain elements use 2D elements. This teaching material is designed with a standard book size, namely A4 (29.7 x 21 cm).

The last step in the planning stage is making a preliminary design. The initial design activity begins with designing a format for teaching materials consisting of a cover, foreword, table of contents, list of images, introduction, materials, assessment, conclusion, bibliography, and author biography.

At the initial design stage, instruments were prepared which included material expert validation instruments, media expert validation instruments, user validation instruments, and treatment instruments, critical thinking ability instruments. The material validation instrument includes four aspects: format of teaching materials, content, language and writing, benefits, and uses. Media validation instruments focus on aspects: of learning, media, and visual design. Meanwhile, the product trial instrument consists of three assessment aspects: use, material explanation, appearance, and application.

The next data is from the development stage, where the product that has been created is realized and then tested for validity by experts. Validation results from material experts show 95% with very valid criteria. Apart from that, the validation of Augmented Reality media reached 95% with very valid criteria. Validation of the test instrument showed a result of 94% with very valid criteria. Then a trial was carried out on 18 students at Merembu 3rd state elementary school to determine the validity based on student responses of the 30 questions tested, 22 questions were declared valid and 8 questions were declared invalid. The questions used in large-scale trials are only questions that are declared valid. Apart from that, reliability testing of the test instruments can be used said reliable and included in the satisfactory category so that the instrument can be used for data collection during large-scale test research.

Next, a validity test was carried out on the treatment instrument carried out by two educational practitioners in two state schools in the city of Mataram and a very high 100% result was obtained, so that the teaching module developed could be used to provide treatment in large-scale tests. Apart from that, regarding the validity of lecturer users, the data on the validity of teaching materials was 94% and was included in the very high validity category. Overall, all aspects contained in the teaching materials and all supporting instruments in this research are declared to be very valid.

Next, a small-scale trial was carried out at Merembu 3rd state elementary school with respondents consisting of: One teacher and five grade 5 students. The results obtained were 91.9 in the very good practicality category. Next, a large-scale trial was carried out to determine practicality and effectiveness and user response. The practicality test results show the practicality percentage is 93% and is included in the very good category. Next, the test results at this large-scale test stage are evaluated. Looking at the descriptive statistics, it is clear that there is a difference between the average value before treatment, namely 63.32 (pretest) and the value after being given treatment, namely 81.14 (posttest) using teaching materials that have been developed.

From this data it can be seen that after implementing integrated Augmented Reality teaching materials, students' critical thinking abilities on digestive organ material increased. Because the average value of student learning outcomes on the pretest is 63.32 < post test 81.14, then it can be interpreted descriptively as there is a difference in the average learning outcomes between before and after treatment using integrated Augmented Reality teaching materials in students' critical thinking abilities on digestive organ material.

Next, to prove whether the difference is really real (significant) or not, it is necessary to interpret the results of the paired sample t test where from the output results of the paired sample t-test using SPSS version 25 above, the sig value is known. (2-tailed) of 0.000. Based on the basis of decision making in the paired sample t-test if the sig value. (2-tailed) < 0.05 then H₀ is rejected and H_a is accepted. In the data above, the sig value. (2-tailed) of 0.000 < 0.05 so it can be concluded that there is a significant difference between the results of the pretest and posttest, which means that it shows that there is an influence of the application of Augmented Reality integrated teaching materials on the critical thinking abilities of grade fifth students on digestive organs, science content in Ampenan 45th state elementary school.

Conclusion

In research and development Augmented Reality integrated teaching materials to improve students' critical thinking skills, obtained the following results:

- 1) Stages development of Augmented Reality integrated teaching materials on digestive system material that is valid, practical and effective through five stages based on the ADDIE development model: namely Analysis, Design, Development, Implementation and Evaluation).
- 2) Based on the results of data analysis, the following are obtained:

a. Validity of Teaching Materials

Based on material experts and media experts, it was found that the validation score for teaching material products was at a score of 95% from media experts, 95% from material experts. Based on this score, it can be concluded that Augmented Reality integrated teaching materials have very high validity.

b. Practicality of Teaching Materials

Practitioner assessments of teaching materials obtained from the questionnaire on the use of teaching materials are as follows:

1. Expert assessment: Lecturer users with a validity score of 94% in the very good category.
 2. Limited trials: teacher users had a validity score of 90% in the very good category and student users had a validity score of 92.3% in the very good category.
 3. Extensive testing: student users with a validity score of 93% in the very good category.
- Based on the results of this user assessment, it can be concluded that the integrated Augmented Reality teaching materials developed have very good practicality.

c. Effectiveness

The effectiveness test was carried out in schools in a wide trial and results were obtained based on the output of the paired sample T-test using SPSS version 25 above, the sig value was known. (2-tailed) of 0.000. So it can be concluded that there is a significant difference between the results of the pretest and posttest, which means that it shows that there is an influence of the application of Augmented Reality integrated teaching materials on the critical thinking abilities of grade fifth students on digestive organs, science and science content at Ampenan 45th state elementary school.

Recommendation

Based on the discussion of research results, several can be proposed as follows.

- 1) It is hoped that the success of research and development in this research can be continued and implemented in the future
- 2) Other researchers who want to develop similar products are expected to pay attention to the characteristics of target users and the availability of supporting resources.
- 3) Users, both teachers and educational practitioners, can apply this product by first providing a good explanation of its use.

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