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The Development of Augmented Reality Based Student Worksheet on Human Respiratory System Course to Improve Critical Thinking Skills of Junior High School

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ABSTRACT

Objective: The development of augmented reality based student is used to improve the critical thinking skills of junior high school science students. This research aims to describe the validity, practicality and effectiveness of augmented reality based student worksheet oh Human Respiratory System course. **Method:** This research applies the ADDIE model was carried out at Jember' 12 Junior High School and the data collection instruments used are observation sheets, validation sheets, student response questionnaires, and test assessment sheets. **Results:** The results obtained are the validity of the product is declared valid with a percentage of 92%, the practicality results are classified as practicaland the effectiveness results are very positive. N-gain results of 0.55 which is included in the moderate category. **Novelty:** Augmented reality-based student worksheet can be used in science learning as an alternative learning media to improve critical thinking skills of junior high school students.

INTRODUCTION

Indonesian education has reached the fourth industrial revolution century. Science and technology are expanding at a quick pace in this century, bringing about changes in the way people learn, such as curricular revisions, learning media, and changes in the technology used. Science learning is one type of learning that is influenced by the advancement of science and technology. Widyaningsih and Japa (2019) define science learning as an interaction between educators and students that takes place both outdoors and indoors and is focused on nature and its surrounds. Science is a methodical study of nature that includes not only the mastery of facts, concepts, information, or principles, but also the process of discovery, scientific method, and scientific attitude.

Teachers as educators in schools are expected to apply science learning to pupils in order to foster talents in the twenty-first century, particularly among junior high students. Critical thinking is one of the 21st century abilities that is vital to apply and can produce pupils to solve an issue (Rubini et al., 2019). According to Agnafia (2019), critical thinking skills are described as a person's ability to reason deeply and support their claims. Students' critical thinking skills can be shown in their capacity to solve issues effectively and systematically, draw conclusions based on true or incorrect information, fully learn a lesson, and are not easily affected by the opinions of others (Meryastiti et al., 2022). Students have critical thinking abilities if they can master all of the signs that exist in critical thinking during the learning process (Lestari et al., 2021). Learners with hight critical thinking skills will be able to review the material provided

ased on prior knowledge, allowing them to select the information they get (Solikhin et al., 2021).

Critical thinking skills are still lacking in Indonesia. Students of Jember' 12 Junior High School have low critical thinking skills as well. The lack of enthusiasm of students in classroom learning is the source of low critical thinking skills in students at Jember' 12 Junior High School (Kartika et al., 2020). Similar findings have been discovered in MTs.Qudwatun Hasanah Mertak Kesambik that students' interest in responding questions posed by the teacher is still limited, and that learning is still remembering (Rasyidi et al., 2020). According to Rosmalinda et al. (2021), 8th grade pupils with poor critical thinking skills. This is recognized from a lack of students' ability to connect content with real life, and there are still many students who have not been able to analyze the faults of a solution technique of a solution procedure. Another source of insufficient critical thinking skills in students, according to Febrianti et al., (2021), is that students continue to get low-level thinking content, therefore pupils have not mastered HOTS test questions. The low ability of students can also be caused by learning media that is not in accordance with the demands of students in certain subjects, especially in the the Human Respiratory System course.

Human respiratory system course is defined as course that integrates concepts, forms, or mechanisms with theoretical features in such a way that requires the use of appropriate learning media to facilitate student understanding. Human respiratory system course is contained in abstract course, making it difficult to observe directly and necessitating numerous particular methods in the learning process. The course of the respiratory system is abstract because it cannot be examined directly, such as the constituent organs of the respiratory system located in the body cavity to the processes that occur in the respiratory system.

The augmented reality-based student worksheet can be understood as a worksheet aided by 3D visualization technology that students can practically access using their smartphones (Nurhidayanti et al., 2022). According to Rianto et al., (2020), augmented reality-based student worksheet student worksheet is described as a teaching course that combines the virtual world in the form of 2 or 3 dimensions to appear real when employed. It can be concluded that augmented reality-based student worksheet is a collection of sheets of paper containing stages of learning activities with the help of virtual technology when used by students.

The usage of augmented reality-based student worksheet adds novelty to course delivery in the classroom (Putra & Winarti, 2021). The application of augmented reality-based student worksheet helps teach and develop students' critical thinking skills since, in addition to writing activities on the work twin, graphics, audio, and video in a medium with a three-dimensional notion are also assisted (Sutanto & Winarni, 2022). This maximizes the course delivered by educators and has an impact on learning effectiveness. This augmented reality-based student worksheet can also provide an overview of abstract concepts for prospective understanding as an effective media in accordance with learning media objectives (Aditama et al., 2019). Augmented reality-based student worksheet can stimulate students' critical thinking about problems and events in everyday life because they can see the object of observation themselves, allowing them to find concepts independently (Prahani et al., 2023; Saphira et al., 2022; Saphira & Prahani, 2022).

RESEARCH METHOD

This type used research and development, which is a research that becomes a reference in updating and expanding the products created to make them look more flawless (Muqdamien et al., 2021). The ADDIE model (Analyze, Design, Develop, Implement, Evaluate) is utilized by researchers in their study designs. The ADDIE development model is a learning development model that refers to a system whose aims can be reached and can be utilized as a guide in creating the next product (Bulhayat et al., 2021).

This research was carried out at Jember' 12 Junior High School. The implementation took place during the even semester of the school year 2022/2023. The population in this study were eighth-grade students at Jember' 12 Junior High School in the 2022/2023 school year. The research sample consists of class VIII B students who meet certain criteria, such as possessing an android, being able to download and run programs from the internet, and being able to execute applications. Techniques for gathering data include observation, interviews, questionnaires, tests, and documentation. Validity test analysis, practicality test analysis, and effectiveness test analysis utilizing N-gain to measure the improvement of students' abilities and analysis of students' responses using student response questionnaires are the data analysis techniques used.

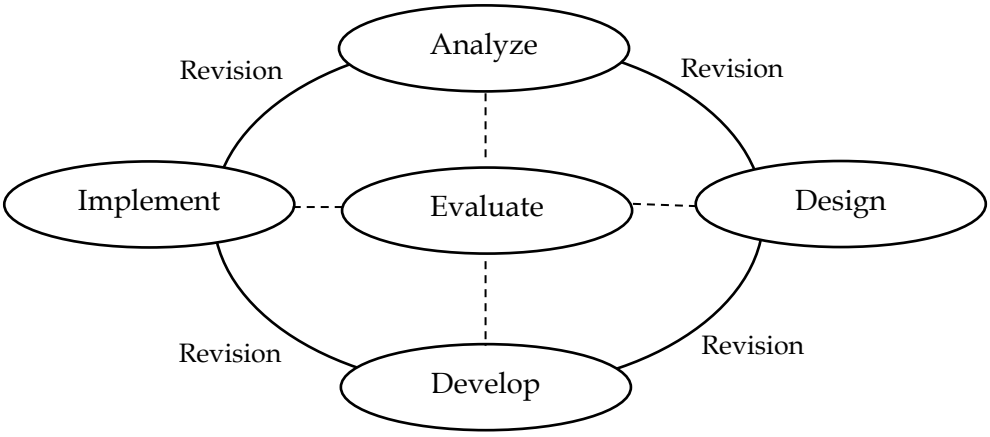


Figure 1. ADDIE development model flow (Branch, 2009).

The ADDIE development model uses the development model, which consists of five stages: analysis, design, development, implementation, and evaluation. In the figure each stage is connected by a dotted line in the diagram, suggesting that there is a reassessment at each stage that allows for tailored changes. Curriculum analysis, student analysis, scenario analysis, and product analysis are all part of the analysis step. Several tasks are carried out throughout the design stage, such as creating lesson plans, student worksheet, augmented reality, and printing evaluation questions. Three experts will use a validation sheet to conduct a validity test on the development stage. During the implementation stage, augmented reality based student worksheet will be used in the classroom. In terms of the assessment stage, research will be conducted to determine the impact of augmented reality based student worksheet on students' critical thinking skills.

The validity of augmented reality based student worksheet is calculated using data analysis techniques based on the value on the validation sheet. The validation sheet was

distributed to three validators: one scientific education lecturer from the University of Jember and two eighth-grade science teachers from Jember' 12 Junior High School. Use the following formula to compute the percentage of validity.

$$V = \frac{\text{Trs}}{\text{Tms}} \times 100\%$$

The validity percentage is marked by v, the result score is Trs, and maximum score is Tms. There are four types of validity eligibility: highly valid, valid, less valid, and invalid. The category is determined by the computation results, which are then altered to meet the score criteria. In terms of practicality, the percentage can be determined using the formula below.

$$P = \frac{\text{Tos}}{\text{Ths}} \times 100\%$$

According to the algorithm, *P* represents the percentage of practicality, Tos represents the overall score earned, and Ths represents the highest overall score. The practicality test is divided into four categories: very practical, practical, less practical, and impractical. The category is determined by the computation results, which are then altered to meet the score criteria. The N-gain formula can be used to calculate the effectiveness test analysis to measure the improvement of critical thinking skills.

$$(g) = \frac{\text{Spostest-Spretest}}{\text{Smaximum-Spretest}}$$

The algorithm defines *(g)* as the average normalized gain score, Spostest as the average final test score, Spretest as the average initial test score, and Smaximum as the ideal maximum score. There are three levels of effectiveness in this test: high, moderate, and low. The effectiveness findings gained afterwards are compared to existing criteria to determine the category.

$$RS = \frac{\text{Vs}}{\text{Ta}} \times 100\%$$

In this algorithm, RS represents the percentage of student replies, Vs represents the voted from student, and Ta represents the total amount. This test has four levels of categories: highly positive, positive, less positive, and not positive. To identify the category, the resulting value will be modified to the existing criteria.

RESULTS AND DISCUSSION

Results

The goal of the development research activities is to create and test augmented reality based student worksheet for validity, practicability, and effectiveness. The creation of augmented reality based meant to supplement junior high school scientific instruction and be utilized as interactive teaching resources. The ADDIE research model was chosen by the researchers in the following steps.

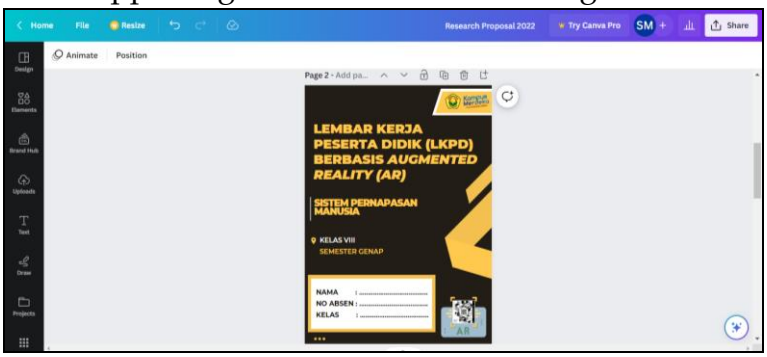
1. Analyze

This step of analysis is carried out through observation and interviews. Curriculum analysis, student analysis, scenario analysis, and product analysis are all part of this stage. The curriculum used in Jember' 12 Junior High School for eight class was still the 2013 revised curriculum, according to the curriculum analysis. Data analysis of student demands revealed that traditional learning media, such as textbooks are still used

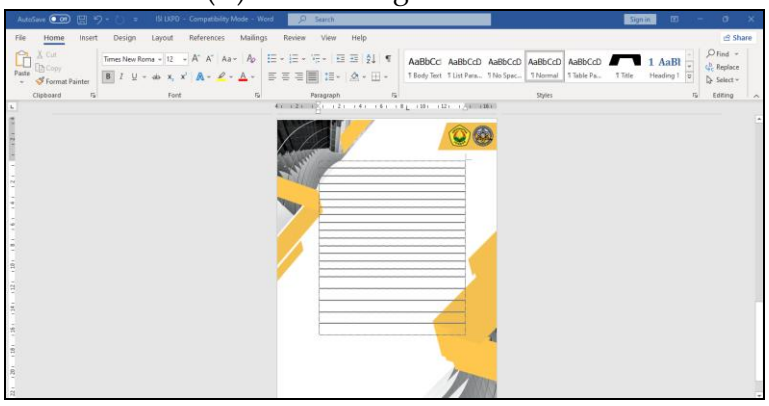
throughout learning. Furthermore, pupils' critical thinking abilities remain low, and their use of technology is inefficient. According to the findings of the scenario analysis, the school authorizes the use of smartphones at school. Product analysis is also carried out in order to adapt the features required in the creation of augmented reality learning media.

2. Design

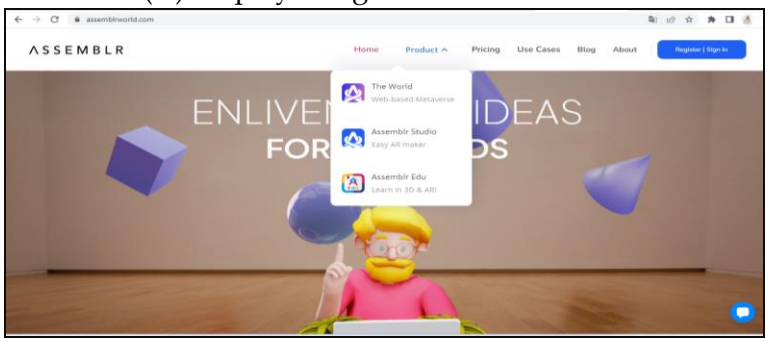
Product design that has been modified in response to the findings of the investigation. The researcherThe researcher created the student worksheet display using Canva (https://www.canva.com/) and Ms.Word during the design stage. The website https://www.assemblrworld.com/ is used to prepare course for augmented reality displays. This section's design includes multiple stages, such as describing the abilities that students must accomplish, gathering course (pictures, videos, 3D objects) required for menu design, and presenting course. The goal of creating this design is to make the learning medium more appealing and functional according to the needs.



(a.) Cover design of student worksheet



(b.) Display design of student worksheet content



(c.) Web view of augmented reality

Figure 2. Design of augmented reality based student worksheet.

Figure 2 depicts the steps involved in producing an augmented reality based student worksheet. Canva site was used to create the student worksheet cover design in image (a.). Picture (b.) depicts the creation of the student worksheet content display design in Microsoft Word, and the last picture (c.) depicts the augmented reality web display. Making this design necessitates selecting the appropriate direction, rotation, scale, color, layout, size adjustment, and lettering. This stage must be taken with caution because it requires concentration and patience throughout the process.

3. Development

This step includes of development carried out after designing augmented reality based student worksheet. The goal of generating augmented reality based student worksheet goods is to produce items that were designed in the previous stage. This augmented reality-based student worksheet must first produce augmented reality course for the human respiratory system. This augmented reality can be accessed through a QR code or by directly accessing the course in the given class. To access augmented reality learning media, use the QR code likely in Figure 3.

Figure 3. QR code augmented reality.

The QR code will begin to process after being scanned. The initial display of augmented reality learning media will show after the user successfully gains access. If the student is successful in accessing it, the following is the initial presentation of the application of augmented reality.

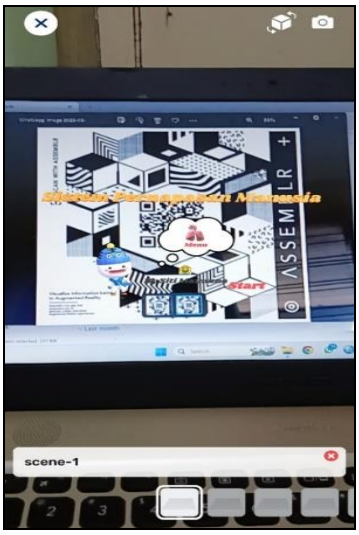


Figure 4. Augmented reality display successfully accessed.

This augmented reality based student worksheet is supported by the assemblr edu application, therefore users must first install the application before they can use augmented reality. This application has various menus, including class, topic, scan, and you (user profile). This learning medium simply uses the class menu, scan, and you (profile). Students who want to view the course in augmented reality will be directed to join another class first, using the code before joining the newly established class. The following is the main page of assemblr edu. Students who successfully join the class after inputting the code provided by the teacher can subsequently find out what activities are available in the class. There are also a homepage, resources, and members menus within the class. Figure 5 is a screenshot of the class menu.

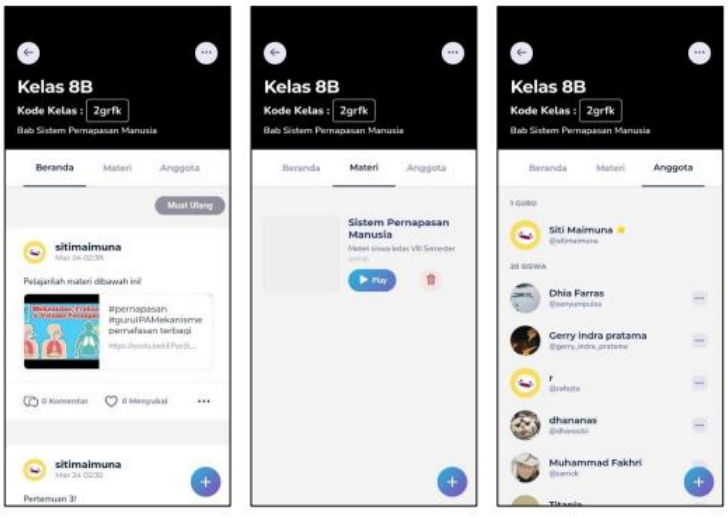


Figure 5. Menu on the class in augmented reality application.

The augmented reality menu comprises of (1) learning tools that contain basic competencies, (2) augmented reality benefits, (3) course, and (4) practice questions. Students will be routed to a Google form with critical thinking skills questions via the question exercise option. Before working on these questions, students must first enter their personal information, such as their complete name and email address. Pictures

and videos are included in the content to help students grasp the topic on the human respiratory system, as well as to see some respiratory organs in 3D. Students can use the icons on each menu display, such as "start" to begin, "next" to proceed to the next page, "back" to return to the previous page, and "round numbers" to access facts or explanations.

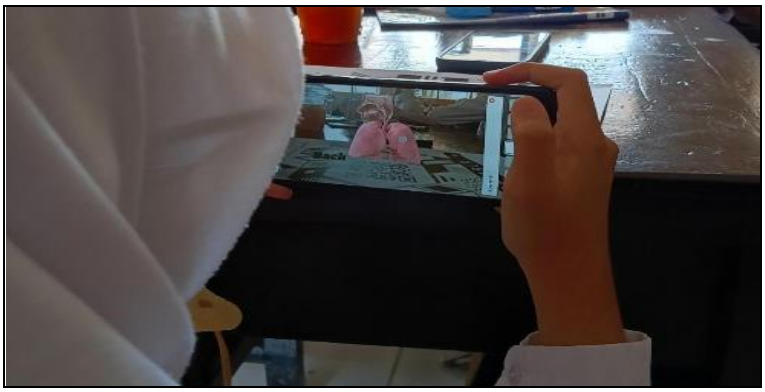


Figure 6. View of augmented reality usage.

The stage following the creation of the augmented reality course is the creation of the student worksheet content. The substance of the student worksheet referred to here is to create instructions for carrying out tasks that must be completed by pupils on the course of the human respiratory system. The contents of this student worksheet must be consistent with the markers of critical thinking skills. The following is the procedure for creating the student worksheet contents in Microsoft Word.

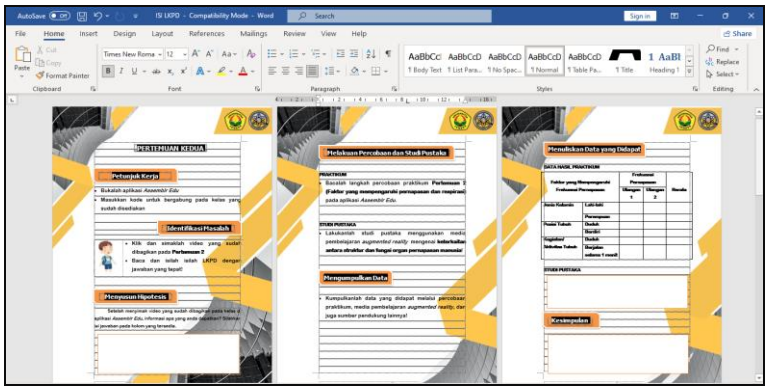


Figure 7. Display of student worksheet content creation.

The validity of augmented reality based student worksheet is determined by the outcomes of three validators' assessments. Two science teachers from Jember' 12 Junior High School and one lecturer are among the three validators. There are four levels of augmented reality learning media assessment: 1 = extremely low, 2 = low, 3 = good, and 4 = very high. Table 1 shows the outcomes of the three validators' evaluations.

Table 1. Results of validation of augmented reality learning media.

Number	Assessment Aspect	Validator Percentage (%)			Average (%)	Category
		1	2	3		

Number	Assessment Aspect	Validator Percentage (%)			Average (%)	Category
		1	2	3		
1.	Contents	83.00	92.00	100.00	92.00	Very Valid
2.	Material	83.00	83.00	100.00	89.00	Very Valid
3.	Presentation	94.00	94.00	100.00	96.00	Very Valid
4.	Language	100.00	100.00	81.00	94.00	Very Valid
5.	Graphics	88.00	94.00	94.00	92.00	Very Valid
Average percentage score		**90.00**	**93.00**	**95.00**	**92.00**	**Very Valid**

4. Implement

At this point, the augmented reality based student worksheet was tested on 31 students from class VIII B at Jember' 12 Junior High School in order to collect data on its application during learning. The implementation data was gathered through the evaluation of three observers during two sessions of learning activities. Table 2 contains statistics on learning implementation.

Table 2. Results of learning implementation analysis.

Activity Aspect	Chapter (%)		Percentage (%)	Category
	2	3		
Distribute student worksheet and AR usage guide book	75.00	100.00	88.00	Very Practical
Explaining the procedures for working on student worksheet and AR guidebooks	100.00	100.00	100.00	Very Practical
Carry out activities in accordance with the direction of the student worksheet event	100.00	92.00	96.00	Very Practical
Prepare experimental tools and course according to the direction of the student worksheet	100.00	83.00	92.00	Very Practical
Conduct experiments and literature studies using augmented reality learning media in accordance with the student worksheet directions	100.00	100.00	100.00	Very Practical
Writing, analyze, and conclude the results of activities in the student worksheet	100.00	75.00	88.00	Very Practical
Present the results of the discussion in the student worksheet activity	75.00	83.00	79.00	Very Practical
Average percentage	**93.00**	**90.00**	**92.00**	**Very Practical**

5. Evaluate

The evaluation stage is the culmination of numerous steps that have been completed. At this step, the generated goods are evaluated using tests to acquire effectiveness data and student response surveys to determine student reactions. The critical thinking skills exam is used as the foundation for getting the findings of the effectiveness study of the use of augmented reality based student worksheet. The test questions, both pretest and posttest, are the same, with a total of six questions containing each critical thinking indicator with an essay style. The average critical thinking test scores can be seen in figure 5.

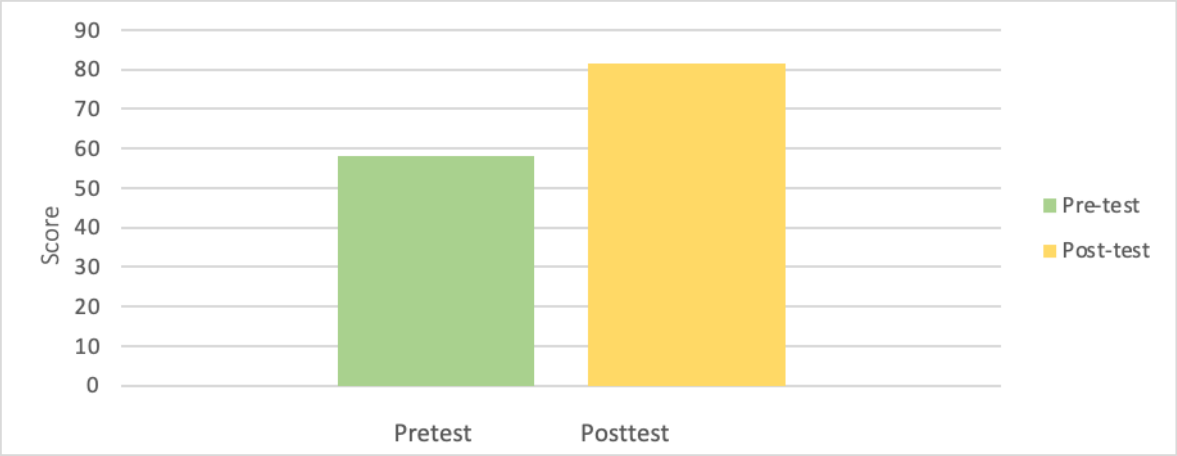


Figure 8. Average critical thinking skills test scores.

Figure 8 shows that students' critical thinking skills were still low prior to the usage of augmented reality based student worksheet in the classroom. The student score was revealed to be 58. In contrast to when augmented reality based student worksheet was used in the classroom, critical thinking ability climbed to 81. The N-gain formula is then used to calculate the amount of efficacy. Table 3 displays the computation results.

Table 3. N-gain analysis result.

Average		*N-gain <g>*	Category
Pretest	**Posttest**		
58.24	**81.36**	**0.55**	**Moderate**

Data analysis in each indicator of critical thinking skills is also required. Table 4 shows the results.

Table 4. N-gain analysis of each critical thinking indicator.

Indicator	N-gain <g>	Category
Interpretation	0.79	High
Analysis	0.47	Moderate
Evaluation	0.60	Moderate
Inference	0.57	Moderate
Explanation	0.48	Moderate
Self-regulation	0.33	Moderate

The effectiveness of augmented reality based student worksheet can also be observed in student answers. Student responses were acquired by giving questionnaires to pupils in class VIII B at SMPN 12 Jember. The student response questionnaire contains 13 questions that address three topics: interest, motivation, and student responses to learning help. Table 5 shows the outcomes.

Table 5. Student response questionnaire result.

Aspect	Percentage (%)	Category
Interest	85.00	Positive
Motivation	88.00	Very Positive
Response	91.00	Very Positive
Average Percentage (%)	**88.00**	**Very Positive**

Discussion

Based on Table 1, the average percentage of overall validity attained is 92.00%. This number indicates that the obtained findings are in the extremely valid category, with a percentage of 90.00% from the first validator, 93.00% from the second validator, and 92.00% from the third validator. The first validator scored 83.00% in the content evaluation aspect, 83.00% in the course aspect, 94.00% in the presentation aspect, 100.00% in the language aspect, and 88.00% in the graphic aspect. The second validator scored 92.00% in the content assessment aspect, 83.00% in the course aspect, 94.00% in the presentation aspect, 100.00% in the language aspect, and 94.00% in the graphics aspect. The third validator scored 100.00% on the content assessment aspect, 100.00% on the course aspect, 100.00% on the presentation aspect, 81.00% on the language aspect, and 94.00% on the graphics aspect. The assessment results show that this augmented reality based student worksheet can be used without modification.

The results of the validity of the content component receive a percentage of 92.00%, which is classified as extremely valid. This signifies that the learning media content has covered course, learning indicators, and learning objectives related to the human respiratory system. Agree with the statement from Handayani et al., (2019) that a product is classed as very valid since the content of the product has been tailored to the basic competencies, indications of critical thinking abilities, and its preparation based on student needs. The validation findings show that the percentage of course is 89.00% with a very valid category. The augmented reality based student worksheet is based on the Human Respiratory System content, with the indicators updated to the critical thinking indicators. Agree with Hendri et al. (2021) that a product is valid if it has the fundamental competencies and subject matter that will be developed as a result of learning objectives. The presentation aspect received 96.00% with a very valid category. The category in this aspect indicates that the presentation of augmented reality learning media is structured, the activities are in accordance with the indications of critical thinking abilities, and the presentation has a different appearance than other learning media. According to Hutama (2016), the job of the presenting apparatus is to evaluate the design of the educational course utilized so that it has its own features.

The language aspect received a 94.00% with a very valid category. This indicates that the product was created with linguistic feasibility, easy-to-understand language, and appropriate text and visuals in mind. A product is regarded to be genuine if the language employed is still prevalent among students and is easy to grasp, clear, and direct. The graphic aspect received a 92.00% with a very valid category. A valid product has an attractive design presentation and video illustrations or graphics relevant to the learning topic (Agustha et al., 2021). According to Table 2, the application of learning when employing augmented reality learning media has an average proportion of 92.00%. The score falls into the very practical category. Each chapter also has a very

practical area, with a rate of 93.00% for the second chapter and 90.00% for the third chapter. This assessment concludes that the implementation of learning using augmented reality based student worksheet is extremely well executed. This is consistent with Zukhrufurrohmah et al. (2018), who argue that the degree of learning implementation can be classified as high if it is accompanied with teaching resources that can help teachers when teaching and are easily comprehended by students. Teaching course can also be called practical if they meet the qualities of practicability, such as simplicity of use for instructors and students and good implementation (Muktiranda et al., 2020).

The analysis of the average N-gain in table 3 yielded an N-gain value of 0.55, indicating that the implementation of augmented reality based student worksheet has an impact on improving students' critical thinking skills when studying Human Respiratory System course. The growth is due to the availability of questions that can train students' critical thinking skills, such as the capacity to formulate a hypothesis, conduct experiments, and analyze issues to find solutions. Novitasari and Puspitawati (2022) agree that the questions in augmented reality based student worksheet can train and develop students' critical thinking skills. Critical thinking skills can experience an increase in N-gain in intermediate criteria.

According to table 4, the N-gain findings obtained for each critical thinking indicator differ. The interpretation indicator has the highest N-gain results of critical thinking ability indicators with the highest improvement results of 0.79. The self-regulation indicator had the lowest growth in critical thinking ability, with an N-gain value of 0.33. Students' underestimation of the problem accounts for the low acquisition of the N-gain value on the self-regulation indicator. These results are reached because students simply solve problems at a glance utilizing images rather than paying thorough attention to the processes that occur in the problem with the clues. According to Khasanah et al., (2020), the questions in the self-regulation indicator cause students to restrain themselves in addressing a problem regarding the important things specified in the problem. The interpretation indicator has the highest N-gain because students may interpret the sequence of presenting issues to discover an answer.

Relevant to Rani et al. (2018)'s research, namely the interpretation indicator as the highest indicator than other indicators because students can interpret well and fully express the truth known and asked connected to the problem presented. Another viewpoint indicates that interpretation has the most significance based on his research findings because students only interpret the meaning of a concept in this indication (Agustine et al., 2020). The interpretation indicator of students' abilities aims to represent the meaning of a problem solution by writing information relevant to the problem in their own language that is simple to understand (Facione, 2018).

The study of the student answer questionnaire data revealed that 13 of the 31 questions were extremely positive. The average percentage attained is 88.00%, with a very good category. The percentage description in each element comprises an interest aspect of 85.00% with a favorable category, a motivation aspect of 88.00% with a very positive category, and a reaction aspect of 91.00% with a very positive category. Positive responses from students via questionnaires can be attributed to the fact that the products generated can enhance learning activities and make them more fascinating because they are provided with many learning variations (Rismayanti et al., 2022). This

will have an effect on students by making it easier for them to absorb learning concepts in the classroom (Novitasari & Puspitawati, 2022).

According to the data acquired, this augmented reality based student worksheet can be well welcomed by students and can be utilized to classroom learning because the response is quite good. According to Hidayah and Kuntjoro (2022), the student response questionnaire can indicate interest in learning using different techniques that guarantee satisfaction for respondents, and response is one of the aspects that affect learning motivation. Based on the validation, practicability, and efficacy of augmented reality based student worksheet, it is possible to infer that the media generated can and should be utilized in science learning. This is because the validation, practicality, and effectiveness categories of outcomes are particularly valid, practical, and effective in improving critical thinking skills. According to Setyawan et al., (2019), augmented reality based student worksheet can be well received by students and is viable to utilize as a learning media to enhance the learning process, both in class and independently.

CONCLUSION

Fundamental Finding : Augmented reality based student worksheet to improve critical thinking skills in this development is declared feasible to be applied in classroom learning, especially on Human Respiratory System course because it obtained a validity score of 92% with a valid category. The practicality of augmented reality based learning is also stated because it received an 92% on the observation sheet analysis. Augmented reality based student worksheet is also effective because it has an n-gain value of 0.55 and an average student response of 88%, indicating that it is very positive. **Implication :** Implications: Augmented reality-based student worksheet can be used in classroom learning, providing a potential for additional study. **Limitation :** The use of augmented reality-based student workbooks is limited by time, and the program cannot be used due to insufficient memory capacity on students' smartphones. **Future Research :** Augmented reality-based student workbooks can be used for reference in further development.

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