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Development of Contextual Based Augmented Reality Science Learning Media to Improve Critical Thinking Skills of Junior High School Students

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Abstract. The critical thinking skills (CTS) of junior high school students remain relatively low, partly due to the limited use of interactive and contextual learning media. This study aims to develop augmented reality (AR)-based science learning media using a contextual approach to enhance students' CTS. The media was developed using the ADDIE model, which includes analysis, design, development, implementation, and evaluation stages. Media validity was assessed by three expert validators, while practicality and effectiveness were tested through observation, questionnaires, and pretest-posttest on grade VII H students at Junior High School 7 Jember. The results showed that the AR-based media had excellent validity (88%) and very high practicality (96.52%), indicating ease of use in learning. Its effectiveness in improving CTS was shown by an average N-Gain score of 0.77 (high category). Students' responses were also very positive, with an average of 81.6%. This AR media features interactive 3D visuals linked to real-life contexts, making science concepts like motion and force easier to understand and helping to foster CTS. Technical challenges, such as internet dependence, can be addressed by using projection tools in the classroom. In conclusion, contextual-based AR media is valid, practical, and effective for supporting 21st-century science learning.
Keywords: Augmented reality, contextual learning, critical thinking, force, learning media, motion

Introduction

Rapid advances in technology have significantly changed the educational landscape, especially in science education. The integration of technology in education is essential to support 21st century learning, which emphasizes essential skills such as communication, collaboration, critical thinking and problem solving (Sinaga, 2023). This explanation suggests that today's new generation is expected to have higher-order skills such as generating and transferring knowledge across fields, using information and communication technologies effectively, and thinking critically (Uçak & Erdem, 2020). This goal is in line with global trends where students are expected to develop higher-order skills, including the ability to generate and transfer knowledge across disciplines, utilize information and communication technologies effectively, and engage in critical thinking (Rahmayani et al., 2024) .

However, there are research gaps that need to be addressed. The goal of improving these high skills turns out to be less proportional to the critical thinking abilities (CTA) of junior high school students in Indonesia which are still relatively low. Fitriarosah (2023) shows that critical thinking indicators such as interpretation, evaluation, and inference are at the level of 15.95, 37.93, and 15.95% respectively, with an overall average of 48.71%. This data indicates an urgent need for innovative and interactive learning media that can adapt to the context of students' lives. A new approach becomes important, namely by creating a learning experience that not only emphasizes on understanding theoretical concepts but also on developing analytical and evaluative capacities that allow students to draw logical conclusions (Wahyuni et al., 2022).

Contextual-based approaches have proven promising in addressing these challenges. By connecting educational content with real-life situations, students can more easily engage in meaningful learning experiences (Mashami et al., 2021). Contextual learning strategies are particularly relevant in science education, where integrating theoretical knowledge with practical applications can improve understanding as well as critical thinking skills (CTS). Given the significant gap in the application of cutting-edge learning technologies such as augmented reality (AR) in junior high schools in Indonesia, the AR approach becomes relevant to be implemented.

Augmented reality technology, which blends virtual elements into the real world to create interactive and realistic three-dimensional visualizations, offers a new approach in science education. Research shows that AR can simplify complex scientific concepts, such as motion and force, making them more accessible and understandable to students (Koumpouros, 2024) . AR-based learning environments have the potential to foster active, efficient, and contextually relevant learning experiences, in line with the needs of modern students. This approach has not been widely applied in Indonesia, so further research can make a significant contribution in improving the quality of science learning.

Although the benefits of AR in education have been proven globally, its adoption in Indonesian schools is still very limited. An interview with a science teacher at junior high school 7 Jember revealed that AR-based science learning media has never been implemented. This emphasizes the need for research into innovative AR-based learning solutions to bridge the gap between theoretical knowledge and practical application, while improving CTS.

The novelty of this research lies in the development of AR-based science learning media with a contextual approach. This combination offers a new solution to bridge theory and practical application while improving CTS. This research also makes a significant contribution by assessing the validity, practicality, and effectiveness of AR learning media, which has not been widely discussed in the Indonesian context. The media designed in this study is relevant to the needs of junior high school students in Indonesia by integrating daily life contexts to create meaningful learning. In addition, this research has the potential to become a model of science education innovation that can be applied more widely in Indonesia.

Several international studies have supported the effectiveness of AR in education. For example, Kamińska et al. (2023) examined the impact of AR on student engagement and found significant improvements in comprehension of complex topics. AR-based learning environments can improve students' motivation and CTS (Pamorti et al., 2024). AR as an effective tool to encourage active learning and improve cognitive outcomes (Rahmasari et al., 2023). These findings provide a strong basis for exploring the potential of AR in junior high schools in Indonesia.

In response to these challenges and opportunities, this research aims to develop AR-based science learning media based on a contextual approach. The main objective is to assess the validity, practicality and effectiveness of this innovative learning media in improving students' CTS. By integrating technology with real-life contexts, this research seeks to contribute to the advancement of educational practices and the development of learning tools that are appropriate to the demands of the digital age. The findings are expected to provide valuable insights for educators and students and address the urgent need for innovative solutions in science education.

Methods

This study is a research and development using the ADDIE model which aims to produce contextual-based augmented reality learning media that is valid, practical, and effective for improving CTS of junior high school students on motion and force material. The ADDIE model was chosen because it is systematic and flexible, including five phases: analysis, design, development, implementation, and evaluation (Rizqia et al., 2024) . The research was conducted in the first semester of the 2024/2025 academic year at junior high school 7 Jember, which was chosen because no similar research had been conducted and the school supported its implementation. The research subjects were students of class VII H junior high school 7 Jember with a total of 34 students. The research sample was taken as many as 10 students using purposive sampling technique, with consideration of student representation based on academic ability to ensure the validity of the research results. This research procedure uses the ADDIE model development procedure which consists of five phases. The phases can be seen in Figure 1.

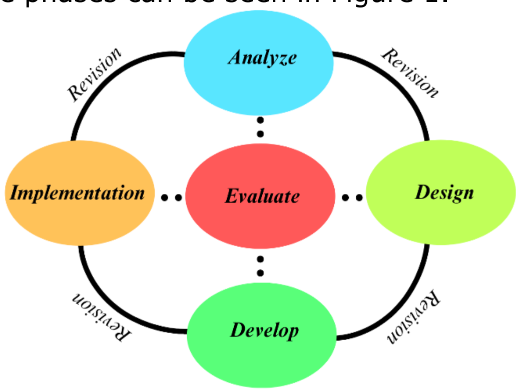

Figure 1. The stages of the ADDIE development model (Branch, 2009).

The stages of this research begin with the analysis stage, which analyzes the needs of students and the curriculum through interviews with teachers and observations of learning conditions in the classroom to ensure the relevance of the media to be developed. The next stage, namely design, is carried out by designing contextual-based augmented reality learning media, which includes making media frameworks, developing content, making flash cards, and preparing CTS tests. The next stage is development with the validity of the media tested by three validators using validation sheets, and revisions are made based on input to ensure product suitability for learning needs. The implementation stage involved media trials for students with teacher assistance to test the practicality and effectiveness of the media. Finally, the evaluation stage was conducted through a posttest to assess the improvement of students' CTS and identify improvements needed in the product (Sholeh et al., 2024) .

Data collection techniques in this study included several methods. Observations were conducted to monitor the implementation of learning by using contextual-based augmented reality media. Interviews were conducted with science teachers and students to identify the obstacles faced during the learning process. Validation questionnaires were filled in by validators to assess the validity level of the learning media developed. Pretest and posttest were used to measure students' CTS before and after using the learning media. The combination of these techniques allows researchers to obtain comprehensive data related to the validity, practicality, and effectiveness of the media.

Data analysis methods in this study include validity analysis, practicality analysis, and effectiveness analysis. Data analysis of contextual-based AR learning media validation was carried out by lecturers at the University of Jember and teachers of junior high school 7 Jember as validators as well as validation data sources. Quantitative data obtained from the validator's check list results on the validation sheet were analyzed using the following formula:

$$V=\left(\frac{Tse}{Tsh}\right)\times 100\% \qquad (1)$$

Remark:
V : Validity
Tse : Total score achieved
Tsh : Total maximum score

The practicality of the contextual-based AR learning media was analyzed based on established criteria using the following formula:

$$P=\left(\frac{Tse}{Tsh}\right)\times 100\% \qquad (2)$$

Remark:
P : Percentage
Tse : Total score achieved
Tsh : Total maximum score

Data analysis of the effectiveness of contextual-based augmented reality learning media through student response analysis and CTA analysis as follows:

a. The percentage of student response can be determined from the value of the student response test questionnaire sheet through the following formula:

$$P=\left(\frac{Tse}{Tsh}\right)\times 100\% \qquad (3)$$

Remark:
P : Percentage
Tse : Total score of data collection results
Sk : Criterion score (highest score x number of aspects x number of respondents)

b. Students' critical thinking skills scores can be determined from pretest-posttest scores using N-Gain.

$$\langle g\rangle = \frac{(Spost)-(Spre)}{(Smaks)-(Spre)} \qquad (4)$$

Remark:
<g> : The n-gain value
Spost : Average posttest score
Spre : Average pretest score
Smaks : Maximum score

The validity percentage of the contextual-based AR science learning media is categorized as presented in the following Table 1.

Table 1. Criteria for the validity of contextual-based AR learning media

Score Validity (%)	Level of Validity
81-100	Very valid
61-80	Valid
41-60	Valid enough
21-40	Invalid

(Source: Rahmat et al., 2024)

Data analysis of the practicality of contextual-based AR learning media with practicality criteria in the following Table 2.

Table 2. Criteria for the practicality of contextual-based AR learning media

Score Practicality (%)	Level of Practicality
81-100	Very practical
61-80	Practical
41-60	Simply
21-40	Less practical
20	Very less practical

(Source: Irawan & Hakim, 2021)

The development of contextual-based AR learning media can be said to be practical if the quality criteria for practicality scores reach 61.00-80.00.

Data analysis of the effectiveness of contextual-based AR learning media through student response analysis and CTA analysis as follows:

a. Student response analysis
The percentage of student response can be determined from the value of the student response test questionnaire sheet through the following formula:

Table 3. Range of student response criteria

Score Response (%)	Practicality level
81-100	Very effective
61-80	Effective
41-60	Simply
21-40	Less effective
20	Very less effective

(Source: Dwiningsih et al., 2018) .

b. Analysis of CTS
Students' CTS scores can be determined from the pretest-posttest using N-Gain. The criteria used to assess the improvement of students' CTS are shown in the Table 4.

Table 4. N-Gain criteria

Score N-Gain (%)	Effectiveness level
$(<g>) < 0.30$	Low
$0.30 < (<g>) \leq 0.70$	Medium
$0.70 \leq (<g>) < 1.0$	High

(Source: Hake, 1998)

The development of contextual-based AR science learning media can be said to be effective if the criteria are worth starting from the range of student response test criteria ≥ 61% and n-gain criteria 0.30 < (<g>) ≤ 0.70.

Results and Discussion

This research was conducted by conducting testing stages in terms of validity, practicality, and effectiveness of contextual-based AR science learning media to improve students' CTS at junior high school 7 Jember. The resulting product is contextual-based AR science learning media, which will be applied by researchers in the odd semester 2024/2025 for class VII H junior high school 7 Jember with motion and force material. This research was carried out based on the stages in the ADDIE development model, which are as follows:

Analyze

Analysis is a process that aims to collect data related to student needs which is divided into curriculum analysis, student characteristics, and material characteristics. Student needs analysis includes determining the learning media needed to improve CTS, namely contextual-based AR science learning media. This learning media presents variations in learning by combining text, animation, 3D models and practice questions, so that information is conveyed more effectively. The curriculum applied at junior high school 7 Jember is currently an independent curriculum, which is prepared by teachers through the preparation of learning outcomes, determining the flow of learning objectives, and adjusting the material for each chapter. The independent curriculum has a positive impact by making students more active in learning and forming good character, because they are given space to explore and express their interests (Agustiana et al., 2023). An analysis of students in class VII H shows that students tend to be passive, answer questions simply without explaining in their own language, and often copy friends' answers. The results of observations and interviews about the learning situation in class VII H, which contains 34 students, show that face-to-face learning uses school textbooks and LKS. Teachers rarely use interactive media, such as PPT and learning videos.

Design

Entering the planning stage, researchers designed learning media, teaching modules, ATP, teacher guide modules and pretest-posttest questions. The learning media was designed based on motion and force materials and equipped with AR features in the form of barcodes integrated in the teacher's guide module and as a student access media. The teaching module also follows the motion and force material, with a time allocation of 10 lesson hours or 5 meetings. Researchers provide description questions that include indicators of students' CTS. The designed learning media can be used by students online through smartphones. The development of contextual-based science learning media is designed with the aim of being more interesting and interactive for students. AR features are uploaded in the form of barcodes. The following are the stages of designing contextual-based AR science learning media

a. Material Collection

Material collection is done to compile more interesting learning materials in the form of contextual-based AR science learning media. This process includes collecting materials, images, designs using assemblr edu, canva, articles, and other interesting texts. All materials are collected in the form of files to facilitate the preparation of contextual-based AR science learning media.

b. Development of contextual-based AR science learning media.

The preparation of AR-based science learning media with a contextual approach for motion and force material begins with conducting a needs analysis. This step aims to identify the understanding and needs of junior high school students related to the concepts of motion and force, and determine how AR can be used effectively to support learning. The analysis is conducted through observation, interviews, or questionnaires, as well as curriculum review to ensure that the media developed is in accordance with the existing competency standards and basic competencies.

The next step is to design AR media so that it has a context that is relevant to students' daily situations, so that learning becomes more real and easy to understand. AR displays can show simulations that show the motion of objects on a flat plane or the effects of gravitational forces in everyday life. This design includes creating a storyboard or content flow that describes the contextual situation in the assemblr edu application, so that when used, students can directly observe how the concepts of motion and force apply in their lives. Finally, the development and testing stages are carried out to ensure the media goes according to plan and is effective in improving students' concept understanding and CTS. The following is an example of contextual-based AR science learning media design using assemblr edu.

Figure 2. Initial display of contextual-based augmented reality science learning media

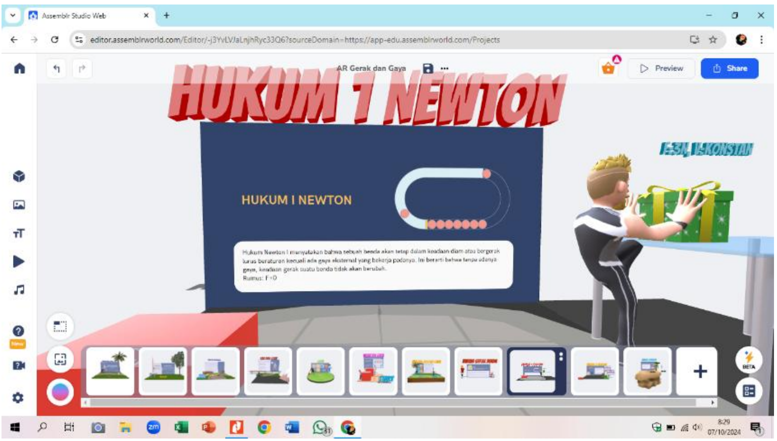

Figure 3. Display of the contents of contextual-based AR science learning media

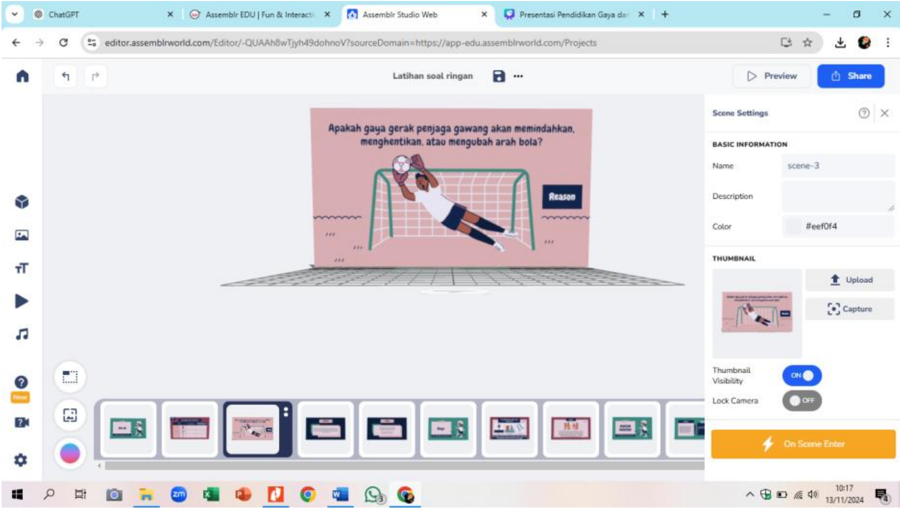

Figure 4. Display of practice questions in contextual-based AR science learning media

Figure 2 shows the initial appearance of AR-based science learning media with a contextual approach, where this page serves as the main interface that displays the title, and navigation to start or select material, designed to attract and motivate students. Figure 3 displays one of the main contents of the media, where students can access AR content that visualizes the concept of motion and force in the context of everyday situations, such as simulations of object motion or gravitational force that can be accessed through barcodes. With the help of visuals and interaction, students can understand science material more deeply and relevant to real life. Figure 4 shows an interactive display of practice questions, which serves to test students' understanding of the concepts they have learned, with various question formats and immediate feedback so that students can find out the extent of their understanding and make improvements if needed.

Development

The results of product development in the form of contextual-based AR science learning media on motion and force material. Validation was conducted by three validators, two lecturers from the University of Jember and one science teacher from junior high school 7 Jember. The validated aspects include material coverage, illustrations, media quality and appearance, and attractiveness. Based on data analysis from the three validators, the contextual AR-based science learning media is included in the highly valid category, because each validated aspect has an important role in improving students' CTS (Socrates & Mufit, 2022). First, the material aspect ensures that the material presented is accurate, relevant, and in accordance with the curriculum, so that students can develop analysis and evaluation skills based on correct information. Second, illustrations involve intuitive visual and functional design, making it easy for students to access and understand the material, which in turn stimulates students to think more critically while exploring the content. Finally, the quality and appearance aspects as well as the attractiveness of the media facilitate an active learning experience, where students can interact directly with virtual objects in a real context, helping them to build concept understanding independently and critically (Hastuti et al., 2025) .

Researchers validated the contextual-based AR science learning media, teaching modules, as well as pretest and posttest question grids. This validation process was carried out by three validators, namely one science education, one physics education lecturer from the University of Jember and one science subject teacher from Junior High

School 7 Jember. The validation results were analyzed by calculating the total average score of the three validators and adjusted to the validity level interval. A recapitulation of the results of the validation of AR-based textbooks can be seen in Table 5.

Table 5. Results of validation of contextual-based AR science learning media

Aspects	Average per aspect (%)	Average validity (%)	Validity level
Material	85	88	Very valid
Illustration	83		
Media quality and appearance	93		
Attractiveness	90		

The validation data displayed in Table 5 shows an average validity of 88%, included in the very valid category. The validity test is a testing stage to measure the accuracy and of the product function in research (Rahmat et al., 2024). The validity of this learning media is appropriate and contextual-based AR science learning media is considered very valid if it scores more than 80% (Nina et al., 2023). Although it has been declared very valid, the validator provides some notes for revision, especially in the aspects of illustration and language which are considered to need a little improvement. The background adjustment on the illustration is adjusted so that it looks sustainable, and the absorption words in the media can be italicized according to Table 6.

Table 6. Revised results of validation of contextual-based AR science learning media

<table>
<tr><th>Validator suggestions and comments</th><th>Before revision</th><th>After revision</th></tr>
<tr><td>Absorbed words can be italicized</td><td>
</td><td>
</td></tr>
<tr><td>Media slides can be assigned pages to make it easier</td><td>
</td><td>
</td></tr>
</table>

This contextual-based AR science learning media has advantages and disadvantages that can be seen in Table 7.

Table 7. weaknesses and advantages of contextual-based AR science learning media

Weaknesses	Pros
The use of contextual-based AR science learning media requires an internet connection.	Contextual-based AR science learning media can be accessed anywhere and anytime with a stable internet network.
The smartphone used needs to have sufficient storage space.	Contextual-based AR science learning media has an attractive appearance that can support the learning process.
Contextual-based AR science learning media is available in the form of barcodes because if printed using markers it is difficult to scan.	Contextual-based AR science learning media is equipped with practice questions to train students' CTS through animations that have been compiled in the assemblr edu application.

The validated learning support device is the teaching module, and the teaching module validation recapitulation can be seen in Table 8.

Table 8. Teaching module validation results

Common Components	Average validator score	Validity (%)	Validity level
General Information	4.56	91	Very valid
Core competencies	4.16	83	Very valid

The teaching module validation results showed a variety of scores on the various aspects assessed. General information received the highest score of 91%, which reflects that this module has a good structure, such as the completeness of the module identity, writing systematics, and general readability. This high score is likely supported by the presentation of information that is clear and easily understood by users.

The recapitulation of the teaching module validation analysis showed that the module was declared very valid with a validity percentage of 91% for general information and 83% for core competencies. Validation was also carried out on pretest and posttest questions.

The core competency aspect only scored 83%, which is relatively lower than other aspects. This may be due to the lack of alignment of the learning indicators with the curriculum objectives, or there are parts of the competencies that are considered less detailed or difficult for students to achieve. The validity of the pretest and posttest questions was also carried out, and the variation in assessment in this section could be caused by differences in the difficulty level of the questions, the suitability of the questions to the competencies being measured, as well as the clarity and effectiveness of the wording of the questions in measuring students' abilities. The difference in value in each of these aspects indicates that the teaching module as a whole is very valid, some aspects can be improved to better align with learning needs and expected learning outcomes. A recapitulation of the validation of pretest and posttest questions can be seen in Table 9.

Table 9. Results of validation of pretest-posttest questions

Aspects	Average per aspect (%)	Average validity (%)	Validity level
Contents	87		
Construct	97	92	Very valid
Language	93		

The recapitulation of the validation analysis of pretest and posttest questions shows that the average percentage of item validity scores reached 92%, which is included in the very valid category. Based on this analysis, the pretest and posttest questions are declared feasible to use to train CTS of junior high school students. The results of the validation of the pretest and posttest questions show that the average validity score of the category is very valid, however, the variation in the value of each item indicates that there are differences in quality in each aspect assessed. The cause of this difference can come from several factors. Questions with high scores tend to have clear wording, are relevant to the competencies being measured, and are able to measure CTS precisely.

Items with slightly lower scores are caused by a lack of clarity in the wording of the questions, a mismatch with the competency indicators, and a difficulty level that is too high, making it less effective in measuring students' skills. This difference can also be caused by variations in the quality of the question stimulus preparation or the completeness of supporting data, such as pictures or context in the question. Nonetheless, the very high average score indicates that this question is already feasible to use, and revisions based on the validators' suggestions will help improve the question to make it more effective for training CTS of junior high school students.

Implementation

Contextual-based AR science learning media was declared valid by the validator. contextual-based AR science learning media was applied to 34 students of class VII H at Junior High School 7 Jember for 5 meetings. Observation data on the implementation of learning using contextual-based AR science learning media was obtained from three observers during the learning process. This observation aims to assess the practicality of contextual-based AR science learning media in supporting learning activities. The recapitulation of the results of the data analysis of learning implementation observations can be seen in Table 10.

Table 10. Learning observation results of contextual-based AR science learning media

Activities	Meeting (%)					Average (%)	Criteria
	1	2	3	4	5		
Ability to open activities	100	94	97	97	94	96.40	Very practical
Material mastery	95	97	93	100	97	96.40	Very practical
Implementation of measures	100	91	100	95	87	94.60	Very practical

Use of learning media	95	97	97	97	95	96.20	Very practical
Evaluation	100	95	100	100	95	98	Very practical
Ability to close the activity	100	97	97	100	94	97.60	Very practical
Average	98.33	95.16	97.33	98.16	93.66	96.52	Very practical

The practicality of contextual-based AR science learning media is assessed from the implementation of the learning process as measured through the implementation observation sheet. The practicality test aims to evaluate whether the product designed is easy to develop, practical for users, and can be accessed anywhere (Irawan & Hakim, 2021). When the learning process takes place, the three observers or observers fill out the observation sheet according to the guidelines in the teaching module provided. The results of the practicality analysis, which are displayed in table 10, show that the average value of the three observers is 96.52% which is included in the very practical category (Rahmat et al., 2024). The statement shows that contextual-based AR science learning media is easy to use during the learning process.

Effective learning includes aspects such as ability to open activities, mastery of material, implementation of steps, use of learning media, evaluation, and ability to close activities have an important role. Good opening skills can capture students' interest and connect new material to their prior knowledge, creating readiness for critical thinking. Educators' mastery of the material ensures the information presented is accurate and in-depth, which is important to support students' analysis. The implementation of systematic learning steps helps maintain a logical learning flow, allowing students to be actively involved in the thinking process (Hidayati et al., 2021). The use of appropriate learning media, such as contextual-based AR, provides an interactive experience that supports deep understanding (Nina et al., 2023). Ongoing evaluation provides students with feedback for reflection and development of critical thinking. Finally, the ability to close the activity by summarizing the material and providing conclusions encourages students to remember, understand, and apply the concepts that have been learned. In this regard, as a result of the study conducted by (Dilmen et al., 2021), in the interviews with the students, the students stated that argumentation-supported AR applications enabled them to learn the subjects better, that the information learned was more permanent thanks to 3D images and the ability to interact with them, that the lessons were very remarkable, fun, and that the applications had a facilitating effect on learning, and that they could visualize abstract concepts in their minds.

Implementation observations show that this product is easily accessible anytime and anywhere, and can increase students' enthusiasm and enthusiasm in learning. Obstacles will not be separated from the application process (Kuswinardi et al., 2023). Slow internet networks or smartphones that are less supportive are certainly some obstacles in the application process. The solution to this obstacle is to display assemblr edu through a projector. Displaying media through a projector is also able to increase the level of student focus by paying more attention to the material explained in the learning process. Similarly, in a doctoral thesis conducted in Turkey, it was observed that they experienced internet connection problems during AR applications (Yildirim et al., 2021).

Evaluation

Data were analyzed to measure the effectiveness of contextual-based AR science learning media in improving CTS. The evaluation stage is also carried out to improve the developed product, so that the product can be improved based on aspects of validity, practicality and effectiveness (Al, 2024). This stage is carried out by giving a *pretest* and *posttest* which aims to train students' CTS. Data were also obtained from student response questionnaires to obtain data in the form of responses to the use of contextual-based augmented reality science learning media. The results of these activities are then analyzed as follows:

a. Critical thinking skills

Analysis of the effectiveness of project-based science modules in improving students' CTS was obtained through pretest and posttest. This test was given to measure the improvement of students' CTS after using contextual-based AR science learning media. The questions given to students are adjusted to the indicators of CTS. The results of the pretest and posttest were analyzed to see the difference in the scores obtained. The average pretest and posttest scores of students in improving CTS can be seen in the following diagram.

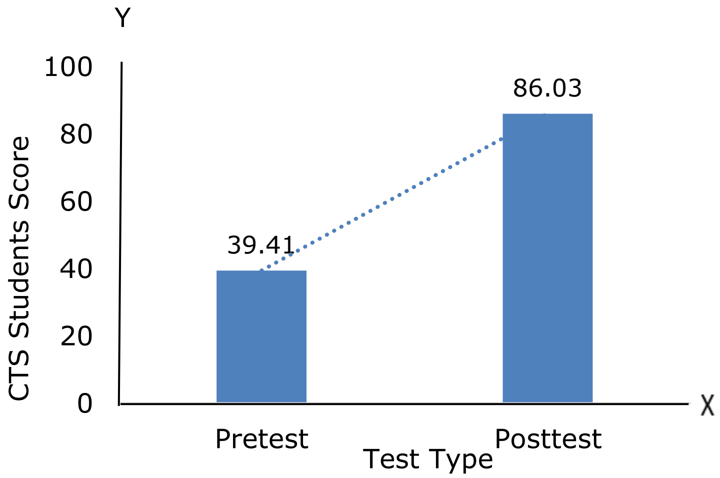

Figure 5. Graph of Average pretest and posttest assessment of students' CTS

The effectiveness of contextual-based AR science learning media in improving students' CTS was tested through *pretests* and posttests attended by 34 students of class VII H junior high school 7 Jember. The percentage of students' CTS was analyzed based on indicators such as focus, reason, inference, situation and clarity as well as student response questionnaires that reflect practitioners' responses to the product. This contextual-based AR science learning media is designed to improve CTS with indicators such as focus, reason, inference, situation and clarity in the material and formative tests (Agustiani et al., 2022).

The formative test consists of five questions that measure CTS, so that it can train students. Research states that modules are effective in improving CTS if there is a significant increase in these abilities (Helen et al., 2023). Some obstacles in developing this media include the difficulty of composing uncomplicated sentences and designing formative tests based on CTS indicators (Sapira & Ansori, 2024). The implementation of this media has several challenges in the classroom including a less conducive classroom atmosphere and students who are not active in the group (Faujiah et al*.,* 2022). The implementation of this learning media was tested in class VII H junior high school 7 Jember with 34 students, starting with a pretest, continued with the use of media, and ended with a posttest to measure the improvement of CTS.

The data in Figure 4 obtained from 34 students who took the pretest amounted to 39.41 while the average on the posttest reached 86.03. These results indicate an increase in CTS of students in class VII H after using contextual-based AR science learning media. Quantitatively assessing the effectiveness of the increase, the pretest and posttest scores were analyzed using the N-Gain formula. The following presents the results of the analysis of the effectiveness of improving students' CTS.

Table 11. The results of the effectiveness analysis of students' CTS.

Component	Score		N-gain <g>	Category
	Pre-test	Post-test		
Number of students	34	34	0.77	High
Average	39.41	86.03		

The N-Gain results for moderate CTA indicators were found in the aspects of focus, reason, inference and clarity with consecutive values of 0.57; 0.47; 0.62; and 0.69, which are classified as moderate. The low analysis ability of students is caused by their lack of ability to choose the right strategy to solve problems through problem analysis (Hayati & Setiawan, 2022). The highest N-Gain is in the situation indicator with a value of 0.77, which is included in the high category. Critical thinking indicators in the situation aspect serve to help students understand the context or conditions of a problem before conducting further analysis. Students are able to identify relevant elements of a problem, understand and formulate questions or problems appropriately, and realize the limitations, assumptions, and initial information available (Saputra & Octavia, 2024).

The results of the N-Gain analysis show an increase in CTS with a value of 0.77 (high category), indicating that the use of media improves CTS. Research (Magdalena et al., 2021) states that effective teaching materials can improve student learning outcomes, which can be seen from the difference in the average pretest and posttest scores of 46.62 (pretest: 39.41; posttest: 86.03), showing a significant increase in CTS.

The effectiveness of using contextual-based AR science learning media was also measured through a response questionnaire filled out by 34 students after using the module. This questionnaire includes indicators regarding aspects of interest, material and language. Based on the results of student responses, it can be seen their opinions about learning with this contextual-based AR science learning media, thus providing an overview of the advantages and disadvantages of the module from the students' point of view. The following results of student response analysis are shown in the Table 12.

Table 12. Results of student response questionnaire analysis

No.	Aspects assessed	Response (%)	Category
1	Interest	79.04	Very good
2	Material	79.15	Very good
3	Language	85.29	Very good
	Average	81.16	very good

The effectiveness of this learning media is also measured from student response questionnaires containing positive and negative statements, which are distributed after the media is used in learning. The questionnaire consists of aspects of interest, material and language with 10 questions that students can answer with a score range of 1-4 (1: disagree, 4: agree). Analysis of the questionnaire results shows that the media is very effective to be applied because it improves students' CTS, with an average percentage of 81.6% in the very good category (Anggraeni et al., 2023). The results of another study showed a student response questionnaire of 77%, also in the excellent category (Obeng-Manu, 2022). The validation, practicality, and effectiveness of the media show that this module is very valid, practical, and effective to support students' CTS in science learning. Another implementation also found that the learning media developed had a validity of 88%, including a very valid category, so it was feasible to use (Rahmat et al., 2024).

Conclusion

Based on the development research, it can be concluded that the contextual-based AR science learning media on motion and force material is valid, practical, and effective in improving students' CTS. The media achieved a validity score of 88%, practicality percentage of 96%, and an effectiveness score with an N-Gain of 0.71 (high category). In addition, students responded positively to the media with a percentage of 81.16%. Therefore, this media is suitable for use in Junior High Schools. Future development should also focus on training other student skills and strengthening supervision of smartphone use during learning.

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