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Enhancing Student Achievement in the Measurement of Objects on Science Material by Developing 3D Hologram Learning Media

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Abstract: Based on observations and interviews, it was discovered that junior high school students' achievement in measuring object material remained low. To improve students' achievement, innovative learning media such as hologram media can be implemented. This research aimed to produce hologram media that is decent and effective in improving student achievement. The hologram media products development follows the ADDIE model, including 3D hologram animation videos creation and a teaching module to aid the learning process. A range of tests were conducted on various products, including justification tests, perception tests, and student achievement tests. The participants consisted of experts, teachers, and students. According to experts, both products were successfully developed and received very decent justification. Teachers and students have also reported excellent perceptions when using the products for learning purposes. According to the achievement test results, students' average post-test score (81.85) is higher than their pre-test score (50.74). The results indicate a normal distribution and significant differences through a normality test and paired sample t-test. According to the N-Gain test results, it showed a 63.41% effectiveness rate, indicating that the learning on the measuring of object material using our hologram media is capable of enhancing student achievement in junior high school.

Keywords: Hologram media; Measuring of object material; Student Achievement

Introduction

The world is currently entering the era of the Industrial Revolution 4.0 which uses a lot of digital technology. The rapid development of this technology can be used to produce higher-quality education in Indonesia. Science is knowledge that is closely related to technology, both in the study of products, processes, attitudes, and applications (Mawadah et al., 2023). Technology in science learning is able to help students become superior, innovative, and able to compete in all fields (Lembani et al., 2023). Thus, teachers can create media by utilizing technological developments to facilitate the science learning process in class. Because by using learning media, the learning process will run more effectively and efficiently (Kirkwood & Price, 2014). Integrating technology into learning science is necessary to develop students' thinking skills and improve their understanding and participation in learning (Cai et al., 2021).

During the process of learning, media can effectively convey information to students by engaging their thoughts, emotions, and focus. In addition, the media can help teachers to teach abstract concepts to be simple concepts in science. However, in reality, the thoughts, feelings, and attention of students in a classroom are still not optimal. Besides, the learning

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process does not go well because students are not yet able to think critically (Herliandry et al., 2018). Consequently, this can cause a lack of motivation among students, leading to a decrease in their achievement (Abdjul et al., 2019). Motivation can be given in several forms such as praise, giving gifts to improve achievement, and the use of learning tools and media (Wibowo, 2021). By inquiry learning model, teachers can solve this problem through a practicum. By practicum activity, the involvement of students in the learning process will foster activeness and a more meaningful learning experience (Tamami et al., 2022). During practicum activities, there are numerous obstacles that one may encounter. These obstacles may include a lack of proficiency in using tools, insufficient materials and tools, a scarcity of diverse learning projects, and inadequate support for learning facilities in the classroom (Rohmantoro et al., 2023). One effective approach to solving this problem is through learning media development, because learning media can channel and message material to students so that they can successfully complete the learning process (Lubis et al., 2023). In addition, teachers can use the learning media as a replacement tool for a practicum by organizing students into groups and assigned to work together in utilizing the media. So that the use of learning media can make effective communication and interaction between teachers and students in the learning process (Amri & Kartono, 2023; Ningrum et al., 2021).

Through observations and interviews with science teachers at nearby junior high schools, it has been discovered that junior high school students struggle with the measurement of object materials resulting in lower academic achievements. Even though the teacher had carried out practicum in the previous learning process, the student learning outcomes were still low. In addition, related to learning media, it was found that teachers did not use a lot of media in this material, either conventional media or innovative media that utilized technology. In fact, research provides a clear example of how the media can help students to become more engaged, motivated, and focused in their studies. It is essential for teachers to recognize the benefits of utilizing media to improve student achievements (Setyowati et al., 2023; Suanto et al., 2023). Using media in education can enhance the clarity and interest of the material being delivered (Pimdee et al., 2023; Setyowati et al., 2023). In some cases, the media is also capable to enhance student skills, such as literacy, critical thinking, and others (Hasanah et al., 2023; Maasawet et al., 2023; Winarni et al., 2020). In addition, the use of learning media can improve the quality of learning so that it attracts students' interest and attention (Doyan et al., 2020; Hoon & Shaharuddin, 2019) .

Research trends indicate that flash-based media is indisputably the most widely developed type of learning media in Indonesia (Setiawan, 2023). The development of learning media is one of the technologies needed in learning so that students can learn independently, explore their skills, and increase student motivation (Firdawati et al., 2021; Rahmat et al., 2023; Susilawati et al., 2022). The development of learning media that are innovative and effective using technology needed recently, such as hologram media. In addition, the development of hologram media for the measurement of object material for middle school students has never been published before by other researchers. This provides an opportunity for researchers to test the feasibility and effectiveness of this hologram media. Therefore, the aim of this study is to develop hologram media that is decent and effective to improve students' achievements in middle school for the measurement of object material.

Method

In this study, the Research and Development (R&D) method was utilized to concentrate on the development, validity, and effectiveness of the product (Deane, 2014). The ADDIE model is used as a guide to research procedures. As seen in Figure 1, this model involves five stages: Assessment/analysis, Design, Development, Implementation, and Evaluation (Lee & Owens, 2004). This model had structured and iterative characteristics to generate a wide range of products such as educational content, instructional methods, learning strategies, and learning materials (Liu & Fan, 2023). The product was developed in the form of 3D hologram videos and a teaching module on the measurement of object material. Details of ADDIE's stages for developing the products are presented in Table 1.

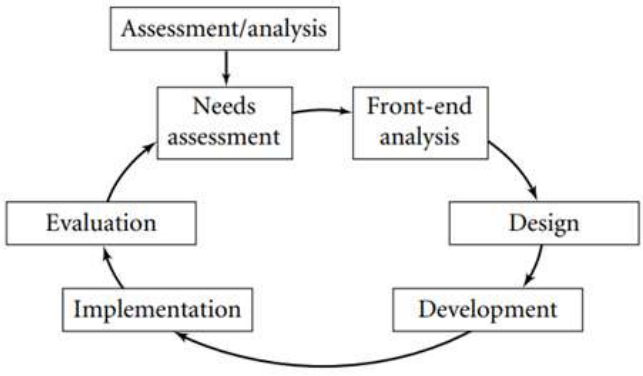

Figure 1. The diagram of ADDIE model by Lee & Owens

The research location was held at the Middle School of Darush Sholihin, city of Batu, province of East Java, Indonesia. The details of respondents in this study were

two experts for the product justification test, a science teacher, and 27 middle school students for the user perception test and the student's achievement test. Several instruments are used, for example, interview sheets for need assessment, validation sheets for product justification, questionnaire sheets for user perception, and pre-test and post-test for student achievement evaluation. The measurement scale for product justification and user perception is a Likert scale with scores of 4, 3, 2, and 1 with the criteria of 'very good', 'good', 'poor', and 'bad', respectively. In addition, we also use the Guttman scale with a score of 1 or 0 with the criteria of 'true' or 'false' for the correctness of the concept in product justification.

Table 1. The Stage, Action, and Description of ADDIE Model

Stage & Action	Description
Analysis (A)	• Identifying problems in the classroom related to student achievements, difficult topics, and learning media through interviews.
• Need assessment	• Analyzing the results of interviews to solve the problem.
• Front-end analysis	
Design (D)	• Determining product specifications for a teaching module and 3D hologram videos, like the size, the shape, and the storyboard.
• Product specification	• Determining the contents of a teaching module and 3D hologram videos.
• Content determination	
Development (D)	• Realizing products in a real form based on the design stage.
• Product realization	• Seeking expert justifications on the decent of products based on the subjects, terms, and media dimensions
• Product justification	
Implementation (I)	• Applying products in the classroom through learning activities
• Product application	• Conducting perception tests on teachers and students for both products
• User perception	
Evaluation (E)	• Evaluating student achievements through pre-test and post-test
• Student achievement evaluation	• Conducting empirical tests through statistic, like normality test, paired sample t-test, and N-gain test

In our data analysis, we employed both quantitative and qualitative methods. The quantitative data was obtained from score calculations, while the qualitative data came from the comments of the respondents. To determine the decent level of the product, we calculated the percentage of scores obtained and divided it by the maximum score. This information is presented in Table 2.

Table 2. The Decent Level of Product

Percentage (%)	Criteria
0 - 20	Not decent
21 - 40	Less decent
41 - 60	Fairly decent
61 - 80	Decent
81- 100	Very decent

In order to properly assess student achievement, statistical methods must be utilized. This necessitates an analysis of both pre-test and post-test data, followed by the performance of normality tests, paired sample t-tests, and N-Gain tests. Generally, the normality test is conducted to determine whether the data used is normally distributed or not. Then, paired sample t-test is used to determine whether there is a significant difference between the pre-test and post-test data (Creswell, 2014). Meanwhile, the N-Gain test is used to determine the effectiveness of products.

Result and Discussion

Analysis (A)

Need assessment

We have carried out a need assessment through interviews with science teachers and students at research locations. From the results of interviews with science teachers, it was found that student achievements in the measurement of object material are still low. The teacher had tried to overcome this problem by using real tools in practicum activity, but the result has not been optimal. The limited number of tools in the laboratory makes students use the tools interchangeably. As a result, students become less focused and have low achievement. This result is consistent with a literature study from the Ref (Abdjul et al., 2019). However, the teacher has not yet produced any media to aid in the comprehension of the learning material. In addition, the results of interviews with students also confirmed that they needed more innovative media for learning.

Front-end Analysis

After conducting a needs assessment, we proceeded with front-end analysis to explore potential solutions. Our goal was to enhance student achievement in the measurement of object material through the development of innovative learning media. Based on our literature review, we identified hologram media as a suitable and effective media to help students stay

focused on learning. This solution was also mentioned in the introduction section.

Design (D)
Product specification

The 3D animated hologram video with a teaching module were designed as hologram media. The specification of the hologram video is in 3D animation with high resolution and black background. This video must be projectable using a one side hologram kit. In order to be projected properly, the video must be upside down so that the object appears upright in the hologram kit. As for the hologram kit, it is available in our laboratory. The teaching module specifications were made in B5 ISO size (25.00 x 17.60 cm), the cover design used the Canva application, and the layout used Microsoft Word. This teaching module is written in Indonesian and then saved in pdf format.

Content Determination

In essence, a teaching module comprises clear guidelines on how to utilize hologram media, the material being taught, and assessments to evaluate student achievement. The material consists of tools to measure length, mass, and time. Then, each material contains an introduction to the tools, parts of the tools, how to use the tools, and how to read the scale in the tools. As for the 3D hologram animation video, the objects chosen to be displayed were ruler, caliper, screw micrometer, ohaus balance, digital balance, analog stopwatch, and digital stopwatch.

Development (D)
Product Realization

We succeeded in making a 3D hologram animation video according to the previous design. Totally, there are seven videos containing ruler objects, vernier calipers, screw micrometers, Ohaus balances, digital balances, analog stopwatches, and digital stopwatches. Each video is shown with the following series of plots, like apperception, introduction to the tools, parts of the tools, how to use the tools, and how to read the scale of the tools. We present the screenshot of 3D hologram animation video in Figure 2.

Figure 2. The 3D hologram animation video product

Figure 3. The screenshot of a teaching module product in Indonesia's language

We also have successfully created a teaching module, and an example of the screenshot is shown in Figure 3. The function of this teaching module is as learning support assisted by hologram media. The teaching module has a cover, preface, table of contents, list of pictures, competency standards, learning objectives, introduction to holograms, guided instructions to use hologram media, subject of material, evaluation tests, bibliography, glossary, and author profile. In addition, this teaching module is also equipped with a QR code and a link that contains a 3D hologram animation video.

Product Justification

Before being used in the field, the products must be tested first by experts to get proper justification or not to be used in learning. We present the results of product justification in Table 3 for 3D hologram animation videos and in Table 4 for a teaching module. From these tables, it appears that the total average yield for 3D hologram animation videos is 94.84% while for a teaching module is 95.43%. With these percentages, all products get the criteria of 'very decent' from the subjects, terms, and media dimensions. This result concludes that the 3D hologram animation videos and a teaching module are very decent to use in classroom learning.

Implementation (I)
Product Application

At this stage, the products are brought into the classroom to be applied in the learning process on the measurement of the object material. To evaluate student achievements in the final stage, we give a pre-test before learning begins. After the test is completed, we teach the material to students using our hologram media. At the end of the learning process, we give a post-test and a questionnaire to students. As media users, teachers were also asked to fill out the questionnaire. Qualitatively, the teacher gave testimony that the hologram media really helped the learning process. The 3D animation hologram videos are made very well, and a teaching module is arranged very easily for students to understand. Therefore, the learning innovations that are carried out increase student motivation in the classroom.

Table 3. The Product Justification for 3D Hologram Video

Dimension	Indicators	Percentage (%)
Subjects	The compatibility of material	100
	The rightness of concept	100
Terms	The simplicity of pronunciation	91.70
	The correctness of grammar	87.50
Media	The goodness of vision	96.40
	The quality of audio	83.30
	Typography	100
	Function and benefit	100
	Total average	94.84

Table 4. The Product Justification for a Teaching Module

Dimension	Indicators	Percentage (%)
Subjects	The compatibility with competence	100
	Material accuracy	87.50
	Material coherence	100
	Material update	75
	The rightness of concept	100
Terms	The simplicity of pronunciation	93.70
	The correctness of grammar	100
Media	The size of module	100
	Cover design	100
	Content layout	90.60
	Total average	95.43

User Perception

Quantitatively, the results of questionnaires by teachers and students through user perception tests related to hologram media are presented in Table 5. From the table, it appears that a teaching module and 3D hologram animation videos as hologram media products got a percentage of 99.50% by teachers and 87.75% by students. These percentages produce criteria of 'very feasible'. It means that the hologram media created and used in the classroom has received a very positive response from teachers and students.

Table 5. The Result of User Perception

Products	Percentage			
	By Teacher (%)	Criteria	By Student (%)	Criteria
3D hologram videos	99.10	Very decent	87.00	Very decent
Teaching module	100.00	Very decent	88.50	Very decent
Average	99.50	Very decent	87.75	Very decent

Evaluation (E)
Student Achievement Evaluation

Evaluation of student achievements on the measurement of object material using hologram media must be executed as a final stage of the ADDIE model. The results of the student's scores for the pre-test and post-test are presented in Table 6. Afterward, the results underwent a Shapiro-Wilk normality test to determine whether they exhibited a normal distribution or not. This was necessary due to the sample number being less than 100 individuals. From Table 6, it appears that the significance value for the pre-test and post-test is more

than 0.05. Thus, it can be concluded that these data are normally distributed.

After knowing the data is normally distributed, the next step is to do a paired sample t-test. The result of the paired sample t-test in Table 7 shows a significance value (2-tailed) of 0.000 (<0.05). It means that there is a significant difference between the student's pre-test and post-test scores.

Table 6. The Result of Normality Test

		Shapiro -Wilk		
	Values	Statistics	df.	Sig.
Pre-test	50.74	0.93	27	0.08
Post-test	81.85	0.96	27	0.38

To find out the effectiveness of student achievements, the N-Gain test was done, and the results are shown in Table 8. From Table 8, the N-Gain scores obtained belong to the category of 'moderate' and 'fairly effective'. Therefore, it indicated that the learning on measurement of object material using hologram media is able to enhance student achievements.

Table 7. Paired Sample t-Test

Pair 1	Paired Differences					
			95% Confidence Interval of the Difference			
	Mean	Std. Deviation	Lower	Upper	t	Sig. (2-tailed)
Pretest - Posttest	-31.11	13.25	-36.35	-25.86	-12.19	.00

Table 8. N-gain Score Test

N-Gain test	Result	Category
N-Gain Score	0.63	Moderate
N-Gain Score (%)	63.41	Fairly effective

It has been proven that utilizing hologram media for teaching the measurement of objects can enhance student achievement in middle school. In addition, learning with hologram media received a very decent response according to teachers and students as users. These findings pertain to a recent study that hologram media used in class increases student's enjoyment and motivation, and also yields positive responses as a learning media (Fokides & Bampoukli, 2022). Several previous studies also obtained similar results, as in the following references (Andini & Setiawan, 2022; Darmawan et al., 2021; Hernawan et al., 2022; Ridsa et al., 2020). Even though the N-Gain test result was in the fairly effective category, the results of the student test experienced a significant increase after learning.

Our hologram media also received proper justification from experts. Because the projection size on our hologram kit was quite large, the hologram object displayed is also much larger. We did this based on suggestions from Ref (Fokides & Bampoukli, 2022). In addition, previous research also stated that hologram media is very suitable for use in the future (Setiawan et al., 2023; Walker, 2013). However, to obtain maximum results, it is necessary to develop hologram media in learning with more advanced technology (Go et al., 2020; Oliveira & Richardson, 2013; Ramachandiran et al., 2019; Son et al., 2018). In addition, the novelty of holograms as learning media is very clear (Setiawan, 2023). So, if this media was developed in large quantities and scale, it will be able to maximize its potential.

Conclusion

The development of hologram media products is in the form of 3D animation hologram videos and a teaching module to support the learning process. Both products were designed and executed successfully, with the 3D animation hologram video receiving a 94.84% rating and the teaching modules receiving a 95.43% rating. These percentages show that the products are very decent according to the justification of the experts. The products were also successfully applied in learning and obtained very decent perceptions from teachers and students. Teachers give a percentage of 99.50% while students give a percentage of 87.75%. Furthermore, the results of the student achievement evaluation, students obtained scores on the pre-test 50.74 and the post-test 81.85. Both of these data are normally distributed through the normality test, and there is a significant difference through the paired sample t-test. As for the results of the N-Gain test, these data get a percentage of 63.41% in the fairly effective category. Therefore, it can be concluded that the use of hologram media in the measurement of object material can improve student achievement in middle school. In addition, the developed hologram media have proved very decent and fairly effective for use in learning.

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Author Contributions

D.A.N. discovered problems related to student achievement and media in learning, compiled research instruments, developed learning media, interviewed, analyzed the data, and drafted the manuscript. A.M.S. reviewed and monitored the progress of the research and provided feedback on the

research. All authors have read and approved the published version of the manuscript. Published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest for this research.

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