JPPIPA 10(6) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The Development of Hologram Media on the Motion of Object in Physics to Improve Students Learning Outcomes in Junior High School

Nella Zada Agustian[1], A. M. Setiawan[2*]

[1] Science Education Study Program, Postgraduate School, Universitas Negeri Malang, Malang, Indonesia.
[2] Department of Science Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Malang, Indonesia.

Received: October 27, 2023
Revised: February 1, 2024
Accepted: June 25, 2024
Published: June 30, 2024

Corresponding Author:
A. M. Setiawan
agung.mulyo.fmipa@um.ac.id

DOI: 10.29303/jppipa.v10i6.5853

Abstract: The quality of science learning in Indonesia is still low based on PISA results. One way to improve the quality of learning is to develop innovative learning media. This study aims to produce a supporting book and hologram animated videos as innovative media for learning science on the motion of objects in physics. Products are developed with the ADDIE model and then tested for their effectiveness. According to the results of the expert validation test for hologram animated video and a supporting book, each product obtains very feasible criteria. Furthermore, the results of user responses test for hologram animated videos, a supporting book, and their ability as innovative media according to users also get very feasible criteria. Then the result of the effectiveness test, the average value for the pre-test was 52.83 and the post-test was 82.17. These values are normally distributed by the Shapiro-Wilk test and had a significant difference by the paired sample t-test. In addition, the N-Gain test, a percentage of 62.10% is obtained with quite effective criteria. Thus, it can be concluded that our hologram media on the motion of objects in physics is very feasible to use and quite effective in improving student learning outcomes.

Keywords: Hologram media; Learning outcomes; The motion of object

Introduction

Learning is an activity of students and educators who interact with learning resources. Learning is carried out by educators to transfer knowledge to students in a learning environment (Zou et al., 2014). To realize the quality of learning, the Indonesian government implemented a curriculum in 2013 that covers all subjects including sciences. Science subjects have been well presented in the curriculum, but science learning in Indonesia, in practice, is still not as expected globally. It is reported from the 2018 Program for International Student Assessment (PISA) that Indonesia ranks 71st of 79 countries. Furthermore, the Indonesian scientific literacy score is still relatively lower than the PISA average score (OECD, 2019). In practice at Indonesian schools, learning science is mostly focused on mastering the material. As a result, learning by the teacher seems monotonous, and students tend to get bored. Students memorize a lot of material, so they easily forget about what they have learned (Castro, 2023). These problems make the learning motivation of students low and decrease their learning outcomes (Castro, 2023). To overcome this problem, teachers need to pay attention to the principles of learning. Regulation of the Indonesian Minister of Education and Culture Number 22 of 2016 explained that one of the learning principles that must be applied at this time is to use information and communication technology media to make learning more efficient and more effective. This current learning era has been integrated with digital technology, so it is easier to facilitate the teaching process by learning media.

How to Cite:
Agustian, N. Z., & Setiawan, A. M. (2024). The Development of Hologram Media on the Motion of Object in Physics to Improve Students Learning Outcomes in Junior High School. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 3404–3413. https://doi.org/10.29303/jppipa.v10i6.5853

Learning media is a useful tool for teachers and students in the learning process (Indriana, 2011). It supports a teaching and learning process controlled by the teacher (Caro et al., 2016; Cárdenas-Sainz et al., 2023). Furthermore, the other benefits of learning media are equating student perceptions with the information delivered, concretizing abstract concepts, representing real objects that cannot be presented in class, displaying objects that are too small or too large, and showing object movements either very fast or very slow (Banda & Nzabahimana, 2023). Learning media is also used to convey messages that can stimulate the mind and attention of students. It can foster students' interests so that the material is easier to understand (Puspitasari & Mulkiyah, 2023). Students' interest to participate in learning activities is also influenced by the teacher's ability to use media. In learning, it is important for a teacher to pay attention to student interests because it can have a positive influence on student understanding (Tuyizere & Yadav, 2023). In addition, many studies in different subjects show a correlation between student interest and learning outcomes (Kay & Kibble, 2016).

In the recent study regarding the trend of developing science learning media in Indonesia, hologram-based media is one of the innovative media that has not been developed by many researchers (Setiawan, 2023). Research by applying three-dimensional media has also not been widely developed (Maharani et al., 2020). A hologram is a result of a technology called holography (Chin & Kim, 2017). Holography is very useful in various fields, especially in education (Rastogi, 2013). The results of a literature study related to holograms as science learning media conclude that this media has great potential to be developed in the future (Setiawan et al., 2023). The advantage of a hologram is to project an object in a three-dimensional way so that students are interested to participate in learning. The unique appearance of objects seen by students can attract them in groups or individually. Research related to holograms as an innovative media for learning science has been proven valid and feasible to use in various research (Andini & Setiawan, 2022; Muhtar et al., 2023; Nawang et al., 2023; Rosiningtias et al., 2022). In addition, another advantage of holograms compared to pictures or videos on handphones is that hologram animation can be observed indirectly. Sudirman (2020) said that the radiation, generated by handphones directly, has been shown to have a negative effect on the user's health, like on the eye and reproductive system.

From the field studies, by interviewing science teachers in Malang City, East Java province, Indonesia, it was found that students experienced an obstacle in science learning. The obstacle is the low motivation of students, and it affects their learning outcomes. For example, the learning outcomes in the motion of objects in physics, and others. This is caused using a lot of modules in the previous teaching process which becomes boring. The low interest of students in learning is caused by learning that is less interesting so students become reluctant to learn (Herliandry et al., 2018). Conversely, students who have high motivation will have enthusiasm and energy in carrying out learning activities (Firdawati et al., 2021). The teacher thinks that students need new media to be used in classroom learning. In addition, the motion of objects is a material of science in the scope of physics related to calculating formulas and applying formulas. It causes a difficult point of view on material and makes their motivation and learning outcomes lower (Jian-Xin et al., 2023). The learning process with many concepts and formulas makes students confused in learning (Nurmayani et al., 2018). Some physics concepts are relatively difficult to understand by students due to several factors, one of which is the lack of application of innovative learning media (Anggraeni et al., 2015). These problems lead to support for the importance of developing hologram media in the motion of objects in physics. This material is considered suitable for hologram media development based on the field study result.

Previous research has proven that hologram media is innovative and attractive, improves understanding of the material, increases learning motivation, and helps teachers to deliver material in the classroom (Darusalam & Pamungkasari, 2019). In addition, this media is able to convey messages or information through 3D objects (Darusalam & Pamungkasari, 2019). 3D visualization in learning can make abstract learning more concrete (Mawadah et al., 2023). This 3D animation has proven to display more interesting visualizations than video only. Hoon (2019) also thinks the same thing about the results of his research using 3D hologram media. Animated videos displayed on holograms are able to attract students' attention, increase motivation, and increase understanding (Hoon & Shaharuddin, 2019). Another study by Ridsa et al. (2020) also explained that the application of 3D hologram media had a positive impact on students' understanding of the material. Thus, hologram media can be used as an alternative increasing students' interest and increasing their understanding of learning material (Ridsa et al., 2020).

Based on the description above, improving the learning quality using innovative media is needed by utilizing technology. This study aims to produce hologram media in science material that is feasible and effective to improve student learning outcomes. The limitation of this study is the media developed specifically on the motion of objects subject and for junior high school students.

Method

The type of this research was research and development (R&D). The product was developed by ADDIE's model and consisted of five stages; Analyze (A), Design (D), Develop (D), Implement (I), and evaluate (E) (Branch, 2009). These five stages were done systematically and evaluated on each stage to obtain optimal results. In addition, this model is used because it has a simple procedure and makes the work to build products easier. The stages of ADDIE's model can be seen in Fig.1. The products were a supporting book and hologram animation videos on motion of object's material. The hologram kit used to display the video is already available in our laboratory.

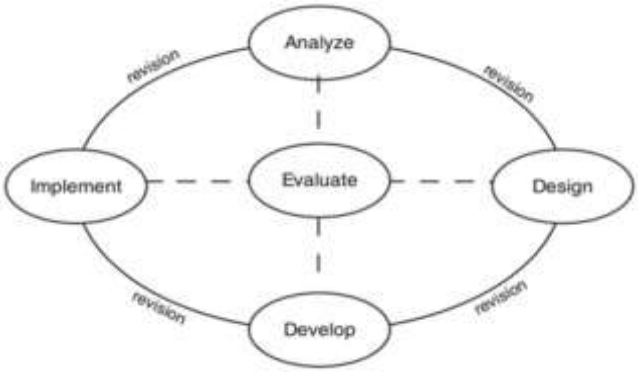

Figure 1. The model of ADDIE stage by Branch

In the first stage, Analyze (A), needs analysis was carried out by literature studies and interviews with science subject teachers. The topics of the interview are the learning media used in the classroom and the learning outcome of student. In the second stage, Design (D), the storyboard of products (a supporting book and hologram animated videos) are designed on the motion of object's material based on the results of the analysis stage. In the third stage, Develop (D), the products were developed to become a real form that was ready to use. At this stage, the aspects of media, material, and language from the products are validated by experts. Then in the fourth stage, Implement (I), the products declared valid and feasible by experts can be applied to students through classroom learning. The fifth stage, Evaluate (E), is the stage for revising the product in all the stages that have been carried out before**.**

Respondent and Data Collection

This research was conducted at junior high school number 11 in Malang city, East Java province, Indonesia. The subjects of this research were 30 students in class VIII who had studied the motion of objects in classroom. While the objects of this research are a supporting book and hologram animated videos on the motion of object's material. To collect data, we used several research instruments like guided interview sheets for teachers, expert validation sheets for lecturers, user responses sheets for science teacher and students, and learning outcome tests for students. The data in this study consisted of quantitative data and qualitative data. Quantitative data are obtained from the following scores, a) the result of expert validation test; b) the result of user responses test; and c) the result of effectiveness test by the pre-experimental design of one group pre-test & post-test. In addition, qualitative data are obtained from comments and suggestions from experts, teachers, and students. Then qualitative data and quantitative data are analyzed by descriptive analysis techniques (Creswell et al., 2018).

Data Analysis

For the measurement scale, we used a Likert scale of 1 to 4 with the following description, 'strongly disagree' for 1, 'disagree' for 2, 'agree' for 3, and 'strongly agree' for 4 (Cohen et al., 2018). This scale applied for expert validation tests and user responses test. A good Likert scale must be expanded from very negative to very positive, like 1 to 4 (W. Creswell & David Creswell, 2018). The use of the Likert scale with 4 scores aims to eliminate doubts due to the central tendency effect on the 5 scores. It is because the middle answer has an uncertain meaning either agree or disagree. Meanwhile, for expert validation test related to the concept, the Guttman scale was used with a score of 0 to 1 (Privitera & Ahlgrim-Delzell, 2019). This scale is used to give answers that are firm, clear, and consistent between 'yes' and 'no'. In addition, the reason for using the Guttman scale in assessing the concept of a material is because the truth of the concept can only be chosen either 'true' for 1 or 'wrong' for 0. The percentage of the score can be obtained by dividing the real score to the maximum score times 100% (Taber, 2018). The percentage now can be interpreted like the criterion in Table 1.

Table 1. The Percentage of Feasibility Criteria

Percentages	Criteria
0 – 20%	Not feasible
21 – 40%	Less feasible
41 – 60%	Quite feasible
61 – 80%	Feasible
81 – 100%	Very feasible

The Research Procedure

The research procedure was carried out first by developing products through the ADDIE model. Then, expert validation tests and user responses tests were executed. Furthermore, the effectiveness test now can be applied to 30 students in class VIII junior high school.

The effectiveness test is taken from student pre-test and post-test data, before and after using the product in the classroom. The number of pre-test and post-test questions is 20 different questions. The normality test was also analyzed to find out whether the data is normally distributed or not. After knowing the data were normally distributed, paired sample t-test was conducted to find out whether there were differences in the results of the pre-test and post-test. Furthermore, the N-Gain test was done to find out how big the difference in learning outcomes scores was before and after learning using our product.

Result and Discussion

Product development with the ADDIE model can be completed properly. The result of the analysis (A) stage through interviews with science teachers in junior high schools shows that there are problems that are often encountered in learning science. The problems are the use of learning media in the classroom which is less innovative and the low student learning outcomes. In previous learning, teachers used common learning media like modules. According to the teacher, the advantage of the module is the comprehensiveness of the material inside while the weakness is the static explanations and pictures. This weakness makes students not so enthusiastic to participate in learning. Therefore, innovative science learning media is needed in the classroom. From the literature study, an innovative learning media that is rarely developed and can be used to attract student's enthusiasm in class is hologram media (Setiawan, 2023; Setiawan et al., 2023). Therefore, the author decided to make a product of a supporting book and hologram animated videos on the motion of object material.

Furthermore, the Design (D) and Develop (D) stages are carried out based on the results of the initial stage. These stages obtain designs and products of hologram animated videos and a supporting book on the motion of object material. Hologram animated videos are designed by creating the plot of storyboards and explaining the motion of objects animated. This video must be able to be displayed on a four-sided hologram kit in the laboratory. The hologram can be seen because of the light that is refracted from the monitor screen to the reflecting plane which is a pyramid shape (Yoo & Kim, 2014). The hologram videos contain animations that are made into four precise parts on one screen. We made five types of videos on the motion of objects in physics. Each video discusses motion at constant velocity and constant acceleration, Newton's 1st Law, Newton's 2nd Law, and Newton's 3rd Law. The hologram video is also equipped with audio that matches the animation shown. The screenshots of the hologram animated video, the hologram kit, and the hologram video displayed on the hologram kit can be seen in Figure 2.

Figure 2. The hologram kit, and the hologram object displayed on the kit

As for a supporting book, the design is made by determining the contents of the book and the structures of the book from the first page to the last. The book is entitled "The supporting book on the motion of object equipped with hologram technology". The size of the book is B5 (17.60 × 25.00 cm) containing 37 pages in pdf format. The contents of the book are the same as the contents of the video. The structure of the book includes the front cover, preface, table of contents, list of tables, list of pictures, learning objectives, introduction to holograms, guidelines for using holograms, concept maps, presentation of material, sample questions, practice questions and answer keys, glossary, profile author, and back cover. In addition, there are hologram videos link or QR codes displayed in each sub-chapter in the book. The screenshot of supporting books can be seen in Fig 3. The text in the screenshot looks small and wrote in the Indonesian language of the author because it is only used as proof that the product has been made properly.

Figure 3. The screenshot of supporting book on the motion of object in physics developed in Indonesian language

The Result of Expert Validation Test

Before being applied in the classroom, the product must be declared feasible by experts. This process is a series of Develop (D) stage which is carried out through expert validation tests. The purpose of this test is to determine whether the products of the hologram animated video and a supporting book are feasible or not to use.

Table 2. The Expert's Validation for Hologram Animated Video

Aspect	Indicator	Percentage
Material	The suitability of content	75.00%
	The coherence of content	87.50%
	The correctness of the concept	100.00%
	Average	87.50%
Language	The clarity of sentences	87.50%
	The use of language	62.50%
	The compatibility of words	87.50%
	Average	79.17%
Media	The quality of visual object	93.75%
	The clarity of audio	91.67%
	The function as hologram video	81.25%
	Average	88.89%

For the product of hologram animated video, the results of the expert validation test are shown in Table 2. In the table, there are 3 aspects to evaluate the video. There are material aspects, language aspects, and media aspects. In the material aspect, the correctness of the concept reaches 100.00%. It means that there is no wrong conception in the video content. However, the suitability of content got the lowest percentage of material aspect because the experts think that the animated object can be delivered in a different way. We did not need to fix it because the average for this aspect is 87.50% with 'very feasible' criteria. In addition, the use of language indicator in Table 2 has the lowest percentage in the language's aspect too. The experts think that it is good enough for junior high school students and there is no need to change. The average of the language aspect is 79.17% with 'feasible' criteria. As for the media aspect, all of indicators reach 'very feasible' criteria with a percentage of 88.89%. Experts said that the hologram animated video is a good product.

Table 3. The Expert's Validation Test for a Supporting Book

Aspect	Indicator	Percentage
Material	The suitability of content	83.34%
	The accuracy of content	68.75%
	The update of content	100.00%
	Encourage understanding	75.00%
	The correctness of the concept	100.00%
	Average	85.42%
Language	The clarity of sentences	83.34%
	The use of language	100.00%
	The dialogue of sentences	75.00%
	The compatibility to age	100.00%
	The accuracy of words	75.00%
	Average	86.67%
Media	The size of the book	75.00%
	The design of the cover	87.50%
	The design of content	83.34%
	Average	81.94%

For the product of a supporting book, the results of the expert validation test are listed in Table 3. As the hologram animation video, the aspects of test were also carried out in the material, language, and media. In the material aspect, the average value obtained 85.42% with 'very feasible' criteria. The indicators of the update of content and the correctness of the concept reach the highest percentages while the accuracy of content reaches the lowest percentage. The comments of experts are also the same as before. Then in the language aspect, the average result was 86.67% with 'very feasible' criteria. The indicator of the use of language and the compatibility to student age have the maximum score while the dialogue of sentences and the accuracy of

words have the minimum score. The validator suggested clarifying the sentences referred to some questions, changing the structure of several sentences, and replacing some words in the text. Meanwhile, in the media aspect, an average result of 81.94% was obtained with 'very feasible' criteria and no need to revise the book although the size of the book indicator has a lower score than the others. The Evaluation (E) stage has been done by revising the product to improve the quality of the book. This improvement aims to make the book easy to understand for readers and did not cause misconceptions. From this expert validation test, we can conclude that the hologram animation video and the supporting books are valid and very feasible to use in the classroom as innovative learning media.

The Result of User Responses Test

The respondents from the user responses test are teachers and students. The product of a supporting book, hologram animated videos, and the ability as innovative media were assessed through a questionnaire. We present the results in Table 4. The average scores obtained from all users were 'very feasible' criteria, with teachers at 99.17% and students at 85.70%.

Table 4. The Result of User Responses

Indicator	Teachers	Students
The hologram animated videos	100.00%	85.92%
The supporting book for hologram video	97.50%	85.08%
The ability as innovative media	100.00%	86.11%
Average (Criteria)	99.17% (Very feasible)	85.70% (Very feasible)

The following are comments from teachers and students regarding this product:

> Teacher: "*This hologram media is built very well, and it is suitable for classical learning. We are very interested in applying this innovative media because we never used hologram media in learning activities before. In addition, if this product is used in class, science learning media in schools will be more varied and it can increase students' learning outcomes*".

> Student: "*The motion of object material now is easy to understand because the animated video explains it briefly, clearly, and not complicated. This media hologram is also very interesting, and we are motivated to study the motion of objects because this product is truly a new learning media for us*".

The evaluation (E) results from teachers and students show that a supporting book and hologram animated videos on the motion of objects in physics as innovative media received a positive response. This statement is relevant to previous research which stated that hologram media received a good response from users and could be used as learning media in class (Jayaputra et al., 2017). Doyan (2020) also has a similar opinion about the use of learning media. The learning media used in learning activities also contribute to attracting students' interest in learning (Doyan et al., 2020).

The Result of Effectiveness Test

In the Implementation (I) stage, a supporting book and hologram animated videos on the motion of objects in physics are applied in classroom learning. The effectiveness test was carried out in a limited way through pre-test and post-test. For the 30 students who took part in the classroom learning, the average result of the pre-test was 52.83 and the post-test was 82.17. The normality test was also done to find out whether the data was normally distributed or not. Because the number of samples is less than 100, the normality test with Shapiro-Wilk was chosen. The results are shown in Table 5. From Table 5, it appears that the significance value for the pre-test was 0.410 and the post-test was 0.108. These two significant values are greater than 0.05, so it means that all data are normally distributed.

Table 5. The Result of Normality Test

Learning outcomes	Value	Shapiro-Wilk		
		Statistic	df.	Sig.
Pre-test	52.83	0.965	30.00	0.410
Post-test	82.17	0.943	30.00	0.108

Furthermore, to find out the difference in student learning outcomes from the scores of pre-test and post-test, a paired sample t-test was executed. The results are shown in Table 6. In Table 6, it is known that the significance value (2-tailed) is 0.000, and it is less than 0.05. It means that there are significant differences between pre-test and post-test. Thus, it indicates that our products developed on the motion of objects in physics can improve student learning outcomes.

To find out how much the pre-test and post-test scores increased, the N-Gain test was executed. The result of the N-Gain test score is 0.62 and it can be seen in Table 7. Because the range of N-gain is in $0.3 \leq g \leq 0.7$ then the category is 'medium'. In percent, the N-Gain test obtained is 62.10% where this value is in the range of 56% - 75% with the 'quite effective' category (Hake, 1999). Therefore, it can be concluded that supporting book and hologram animated videos as innovative media developed on the motion of objects are quite

effective in improving student learning outcomes. Learning media is said to be effective if it can improve student understanding and mastery of the concepts based on student learning outcomes (Nasution & Restuati, 2019). The availability of adequate learning facilities affects student success (Ramdani et al., 2020).

Table 6. Paired Sample t-Test

	Paired Differences						
			95% Confidence Interval of the Difference				
Pair 1	Mean	Std. Deviation	Lower	Upper	t	df.	Sig. (2-tailed)
Pre-test - Post-test	-29.33	10.96	-33.43	-25.24	-14.65	29.00	0.00

Table 7. The Result of N-Gain test

N-Gain test	Result	Category
N-Gain score	0.62	Medium
N-Gain score (%)	62.10	Quite effective

The hologram as a learning media has very potential to develop in the future because the 3D animations can attract students' attention and increase students' motivation (Fokides & Bampoukli, 2022; Setiawan et al., 2023). Therefore, this media can improve student learning outcomes in the classroom (Hoon & Shaharuddin, 2019). Motivation in learning is one of the factors that can affect student learning outcomes (Doyan et al., 2018). Students who are motivated in learning will have a better understanding of concepts (Khaerunnisak, 2018). The advantage of hologram media is the ability to display objects in three-dimensional form as representative of real objects or animations (Buah-Bassuah et al., 2007; Gafur et al., 2019; Hobson et al., 2013). In addition, hologram media can be used in various subjects, such as history, science, such as history, science, and astronomy (Anggirawati et al., 2022; Darmawan et al., 2021; Jafari, 2023; Mavrikios et al., 2019; Okulu & Ünver, 2016; Sudeep, 2013). Hologram media is more optimal for use in offline classrooms. Meanwhile, to support online learning, the use of holograms is only through learning videos.

Conclusion

This study aims to develop hologram media for science learning. The products consist of a supporting book and hologram animated videos on the motion of objects in physics. These products are developed with the ADDIE model and then tested for their effectiveness. The data obtained are a) the expert validation test related to concepts, language, and media; b) the user responses test; and c) the effectiveness test. The results of the expert validation test on the aspects of material, language, and media for the hologram animated videos are 87.50%, 79.17%, and 85.83% while for a supporting book are 85.42%, 86.67%, and 81.94%, respectively. These percentages show that all products reach very feasible criteria. Furthermore, the results of the user responses test of the products and their ability as an innovative media from the teacher was 99.17% and from students was 85.70%. These values also indicate that each product is very feasible to use in the classroom. Then, the effectiveness test results obtained an average value of 52.83 for the pre-test and 82.17 for the post-test. These values are normally distributed by the Shapiro-Wilk test and had a significant difference by the paired sample t-test. Finally, with the N-Gain test, 62.10% was obtained with quite effective criteria. Based on these results, it can be concluded that a supporting book and hologram animated videos as innovative media for science learning on the motion of objects in physics are very feasible to use and quite effective in improving student learning outcomes.

Acknowledgments
Thanks to the Universitas Negeri Malang (UM) for funding this theses publication.

Author Contributions
Discover problems related to student achievement, compile research instruments, develop learning media, writing-original draft, N.Z.A; provide concept ideas, writing-review and editing, monitoring the progress of the research and provide feedback on the research, A.M.S. All authors contributed to the content and every section of this article. We have read and agreed to published version manuscript.

Funding
The APC was funded by internal funding of Universitas Negeri Malang in a theses publication's grant, 2023.

Conflicts of Interest
The authors state that there is no conflict of interest.

References

Andini, P. A., & Setiawan, A. M. (2022). Developing Content for 4-Side Hologram Media: E-Book and Hologram Video on Sound Material for Junior High School Students. *Journal of Disruptive Learning Innovation (JODLI)*, *4*(1), 53–62. Retrieved from https://journal2.um.ac.id/index.php/jodli/article/view/36764/11436

Anggirawati, N. M. D., Kanya, N. L. P. A., Srilaksmi, I. A. A., & Sari, K. W. K. (2022). Virtual Hologram Learning As A Publishing Media Of Nusantara

Culture, Study Case: Mabayang-Bayang Tradition In Sengkiding Village. *Sociae Polites*, *23*(1), 265–277. Retrieved from https://doi.org/10.33541/sp.v23i1.4107

Anggraeni, D. M., Susilawati, S., & Gunawan, G. (2015). Pengaruh Media Pembelajaran Berbasis Moodle Terhadap Peningkatan Kemampuan Generik Sains Siswa SMK. *Jurnal Penelitian Pendidikan IPA*, *1*(1). https://doi.org/10.29303/jppipa.v1i1.256

Banda, H. J., & Nzabahimana, J. (2023). The Impact of Physics Education Technology (PhET) Interactive Simulation-Based Learning on Motivation and Academic Achievement Among Malawian Physics Students. *Journal of Science Education and Technology*, *32*(1), 127–141. https://doi.org/10.1007/s10956-022-10010-3

Branch, R. M. (2009). Instructional Design: The ADDIE Approach. In *Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship*. Springer. https://doi.org/10.1007/978-3-319-15347-6_300893

Buah-Bassuah, P. K., Vannoni, M., & Molesini, G. (2007). One-step real-image reflection holograms. *European Journal of Physics*, *28*(2), 359–365. https://doi.org/10.1088/0143-0807/28/2/021

Cárdenas-Sainz, B. A., Barrón-Estrada, M. L., Zatarain-Cabada, R., & Chavez-Echeagaray, M. E. (2023). Evaluation of eXtended reality (XR) technology on motivation for learning physics among students in mexican schools. *Computers & Education: X Reality*, *3*, 100036. https://doi.org/10.1016/j.cexr.2023.100036

Caro, D. H., Lenkeit, J., & Kyriakides, L. (2016). Teaching strategies and differential effectiveness across learning contexts: Evidence from PISA 2012. *Studies in Educational Evaluation*, *49*, 30–41. https://doi.org/10.1016/J.STUEDUC.2016.03.005

Castro, E. A. M. (2023). Analysis of Problem Solving Ability of First Middle School Students in Learning Science. *Integrated Science Education Journal*, *4*(2), 43–53. https://doi.org/10.37251/isej.v4i2.329

Chin, H., & Kim, M.-J. (2017). Converged Study of Influencing Consumer Factors on Hologram Media Experience. *Journal of the Korea Convergence Society*, *8*(1), 149–154. https://doi.org/10.15207/jkcs.2017.8.1.149

Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education* (8th ed.). Routledge, Taylor & Francis Group.

Creswell, J. W., & David Creswell, J. (2018). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches* (5th ed.). SAGE Publications, Inc.

Darmawan, D., Hernawan, A. H., Septiana, A. I., Rachman, I., & Kodama, Y. (2021). Developing of Hologram Multimedia for Speed Learning Through Bio-Communication. *Journal of Hunan University Natural Sciences*, *48*(8). Retrieved from http://www.jonuns.com/index.php/journal/article/view/686

Darusalam, U., & Pamungkasari, P. D. (2019). Wavelet Transform on Digital Rainbow Hologram based on Spectral Compression for Quality Enhancement in 3D Display Media. *Makara Journal of Technology*, *23*(1), 1. https://doi.org/10.7454/mst.v23i1.3107

Doyan, A., Susilawati, S., & Hardiyansyah, H. (2020). Development of Natural Science Learning Tools with Guided Inquiry Model Assisted by Real Media to Improve Students' Scientific Creativity and Science Process Skills. *Jurnal Penelitian Pendidikan IPA*, *7*(1), 15. https://doi.org/10.29303/jppipa.v7i1.485

Doyan, A., Taufik, M., & Anjani, R. (2018). Pengaruh Pendekatan Multi Representasi Terhadap Hasil Belajar Fisika Ditinjau Dari Motivasi Belajar Peserta Didik. *Jurnal Penelitian Pendidikan IPA*, *4*(1). https://doi.org/10.29303/jppipa.v4i1.99

Firdawati, R., Maison, M., & Nazarudin, N. (2021). Development of Mobile Learning Media on Newton's Laws Using the Appy Pie Application. *Jurnal Penelitian Pendidikan IPA*, *7*(2), 202–206. https://doi.org/10.29303/jppipa.v7i2.599

Fokides, E., & Bampoukli, I.-A. (2022). Are hologram-like pyramid projections of an educational value? Results of a project in primary school settings. *Journal of Computers in Education*, 1–21. https://doi.org/10.1007/s40692-022-00255-7

Gafur, I. A., Zulfarina, Z., & Yustina, Y. (2019). Mixed Reality Application as a Learning System of Motion Systems using Pyramid Hologram Technology. *Journal of Physics: Conference Series*, *1351*(1). https://doi.org/10.1088/1742-6596/1351/1/012077

Hake. (1999). *Analyzing Change/Gain Scores*. Dept. of Physics Indiana University.

Herliandry, L. D., Harjono, A., & 'Ardhuha, J. (2018). Kemampuan Berpikir Kritis Fisika Peserta Didik Kelas X Dengan Model Brain Based Learning. *Jurnal Penelitian Pendidikan IPA*, *5*(1), 39–47. https://doi.org/10.29303/jppipa.v5i1.166

Hobson, P. R., Nebrensky, J. J., & Reid, I. D. (2013). Challenges in using GPUs for the real-time reconstruction of digital hologram images. *Journal of Physics: Conference Series*, *415*(1). https://doi.org/10.1088/1742-6596/415/1/012042

Hoon, L. N., & Shaharuddin, S. S. (2019). Learning Effectiveness of 3D Hologram Animation on Primary School Learners. *Journal of Visual Art and Design*, *11*(2), 93–104. https://doi.org/10.5614/j.vad.2019.11.2.2

Indriana, D. (2011). *Ragam Alat Bantu Media Pembelajaran*. PT. Diva Press.

Jafari, E. (2023). Explanation of the views and opinions regarding the education strategies for using 3D hologram technology as an educational media. *Educational Media International*, 1–25. https://doi.org/10.1080/09523987.2023.2262194

Jian-Xin, Y., Yu-Xuan, X., Tian, L., Chu-Fan, D., Yu-Ying, G., & Fortus, D. (2023). Disciplinary Learning Motivation and Its External Influencing Factors: Taking Physics in a "Selection Crisis" as an example. *Research in Science Education*, *53*(4), 823–839. https://doi.org/10.1007/s11165-023-10112-x

Kay, D., & Kibble, J. (2016). Learning theories 101: Application to everyday teaching and scholarship. *Advances in Physiology Education*, *40*(1), 17–25. https://doi.org/10.1152/advan.00132.2015

Khaerunnisak, K. (2018). Peningkatan Pemahaman Konsep dan Motivasi Belajar Siswa Melalui Simulasi Physic Education Technology (PhET). *Jurnal Penelitian Pendidikan IPA*, *4*(2), 7–12. https://doi.org/10.29303/jppipa.v4i2.109

Maharani, R. J. P., Taufik, M., Ayub, S., & Rokhmat, J. (2020). Pengaruh Model Pembelajaran Inkuiri dengan Bantuan Media Tiga Dimensi Terhadap Keterampilan Proses Sains dan Hasil Belajar Fisika Peserta Didik. *Jurnal Penelitian Pendidikan IPA*, *6*(1), 113. https://doi.org/10.29303/jppipa.v6i1.326

Mavrikios, D., Alexopoulos, K., Georgoulias, K., Makris, S., Michalos, G., & Chryssolouris, G. (2019). Using Holograms for visualizing and interacting with educational content in a Teaching Factory. *Procedia Manufacturing*, *31*, 404–410. https://doi.org/10.1016/j.promfg.2019.03.063

Mawadah, N. V., Ikhsan, J., Suyanta, Nurohman, S., & Rejeki, S. (2023). 3D Visualization Trends in Science Learning: Content Analysis. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 397–403. https://doi.org/10.29303/jppipa.v9i8.3864

Muhtar, P. D. R., Munzil, & Setiawan, A. M. (2023). Development of learning media based on 3D hologram on solar system materials. *AIP Conference Proceedings*, *2572*. https://doi.org/10.1063/5.0118343

Nasution, S. H., & Restuati, M. (2019). Developing the Mobile Learning-based Instructional Media of Excretory Systems in Increasing Students' Concept Mastery at SMAN 1 Delitua. *Advances in Social Science, Education and Humanities Research*, *384*, 94–95. Retrieved from https://www.atlantis-press.com/proceedings/aisteel-19/125928343

Nawang, M. D., Munzil, M., & Setiawan, A. M. (2023). The validity of 3D hologram-based learning media development on earth layer material in SMP/MTS. *AIP Conference Proceedings*, *2673*. https://doi.org/10.1063/5.0125168

Nurmayani, L., Doyan, A., & Nyoman Sri Putu Verawati, N. (2018). Pengaruh Model Pembelajaran Inkuiri Terbimbing Terhadap Hasil Belajar Fisika Peserta Didik. *Jurnal Penelitian Pendidikan IPA*, *4*(2), 23–28. https://doi.org/10.29303/jpft.v4i1.548

OECD. (2019). *PISA 2018 Result in Focus*. Retrieved from https://www.oecd.org/pisa/Combined_Executive_Summaries_PISA_2018.pdf

Okulu, H. Z., & Ünver, A. O. (2016). Bring Cosmos Into the Classroom: 3D Hologram. *Education Research Highlights in Mathematics, Science and Technology*, 81. Retrieved from https://www.isres.org/bring-cosmos-into-the-classroom-3d-hologram-30-s.html

Privitera, G. J., & Ahlgrim-Delzell, L. (2019). *Research Methods for Education*. SAGE Publications, Inc.

Puspitasari, R. D., & Mulkiyah, U. (2023). Analysis in Using Learning Media to Increase Student Motivation of Learning Physics. *Journal Corner of Education, Linguistics, and Literature*, *2*(3), 258–264. https://doi.org/10.54012/jcell.v2i3.132

Rahmawati, D., Wahyuni, S., & Yushardi. (2017). Pengembangan Media Pembelajaran Flip Book Pada Materi Gerak Benda Di SMP. *Jurnal Pembelajaran Fisika*, *6*(4), 326–332. https://doi.org/10.19184/jpf.v6i4.6213

Ramdani, A., Jufri, A. W., Jamaluddin, J., & Setiadi, D. (2020). Kemampuan Berpikir Kritis dan Penguasaan Konsep Dasar IPA Peserta Didik. *Jurnal Penelitian Pendidikan IPA*, *6*(1), 119. https://doi.org/10.29303/jppipa.v6i1.388

Rastogi. (2013). *Holographic Interferometry: Principles and Methods*. Spinger Verlag.

Ridsa, A., Sideng, U., & Suprapta. (2020). Effectiveness of the Use of 3D Hologram Learning Media in Improving Student Learning Outcomes in SMA Negeri 2 Majene. *Jurnal LaGeografia*, *18*(3), 191–208. https://doi.org/10.35580/lageografia.v18i3.13607

Rosiningtias, W., Sugiyanto, & Setiawan, A. M. (2022). Development of Digital 3D-Based Learning Media Light Materials and Optical Instruments Utilizing Holography Technology to Improve Students' Concept Understanding. *AIP Conference Proceedings*, *2600*. https://doi.org/10.1063/5.0113657

Setiawan, A. M. (2023). The trend of developing science learning media in Indonesia. *AIP Conference Proceedings*, *2572*. https://doi.org/10.1063/5.0118338

Setiawan, A. M., Munzil, & Sugiyanto. (2023). A literature study of hologram as a science learning

media. *AIP Conference Proceedings*, *2595*. https://doi.org/10.1063/5.0123700

Sudeep, U. (2013). Use of 3 D Hologram Technology in Engineering Education. *International Conference on Emerging Trends in Engineering (SICETE)*, 62–67. Retrieved from https://iosrjournals.org/iosr-jmce/papers/sicete(mech)-volume4/43.pdf

Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education*, *48*(6), 1273–1296. https://doi.org/10.1007/S11165-016-9602-2/TABLES/1

Tuyizere, G., & Yadav, L. L. (2023). Effect of interactive computer simulations on academic performance and learning motivation of Rwandan students in Atomic Physics. *International Journal of Evaluation and Research in Education*, *12*(1), 252–259. https://doi.org/10.11591/ijere.v12i1.23617

Yoo, H., & Kim, H. (2014). On study of the hologram display using mirror in interactive media arts. *Information (Japan)*, *17*(9), 4159–4164. Retrieved from https://www.proquest.com/docview/1625136078?fromopenview=true&pq-origsite=gscholar

Zou, F., Wang, L., Hei, X., Chen, D., & Yang, D. (2014). Teaching–learning-based optimization with dynamic group strategy for global optimization. *Information Sciences*, *273*, 112–131. https://doi.org/10.1016/J.INS.2014.03.038