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Development of Android-based Interactive Learning Media to Improve Student Understanding Through Experiments on Optical Equipment Materials

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Abstract

Learning media based on the Industrial Revolution 4.0 are required to link learning with technical advancements and dramatically improve the learning experience. This study aims to (1) create a product in the form of Android-based mobile-learning media that can carry out virtual experiments on learning about image creation in mirrors. (2) Assessing the practicality of the learning medium created for conducting experiments. (3) Understanding students' reactions to learning media based on Android. (4) Understanding students' comprehension of experiments utilizing the media generated. This research is development research, or R&D, based on the ADDIE development paradigm. There are five stages: 1) analysis, 2) design, 3) development, 4) implementation, and 5) evaluation. The subjects in this research were 28 class XI Science students. This research design is a one-group pretest-posttest design. Questionnaires and interviews were used to collect data regarding suitability and student responses in this research. The data analysis technique employed in this research uses the statistical Wilcoxon and n-gain tests. The Wilcoxon test results obtained a sign value $(0.000) < 0.05$, indicating differences in student learning outcomes before and after treatment, and the N-Gain test results showed that 50% of students had high understanding and 32% had moderate understanding. So the research findings reveal the feasibility of using Android-based interactive learning media to boost student knowledge through experiments on optical materials.

Keywords: Andromo; Interactive multimedia; Physics virtual laboratory; Student understanding

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INTRODUCTION

Physics is a subject related to everyday life. Physics is a scientific discipline built on the interaction between theory and experiment (Redish & Kuo, 2015; Wilcox &

Lewandowski, 2017). Therefore, learning physics in schools should not just transfer theory to students. One strategy to accomplish this is to routinely conduct physics experiments in which students



take a direct role and are driven to have a greater desire to learn physics, hence reducing the weak notions that commonly develop in students. Through experimental activities, students can observe, analyze, carry out, and draw conclusions about a particular object, situation, or process when involved (Gina et al., 2022; Maknun, 2020). Experimental activities can help you enhance your abilities, competencies, and conceptual understanding, allowing you to fulfill your physics learning goals and gain valuable physics knowledge.

Experiments are essential in learning physics, but experimental activities in schools are often rarely carried out (Arista & Kuswanto, 2018; Handayani & Khanafiyah, 2014). The causal factors found were implementing learning in schools using traditional methods, inadequate facilities, and not providing opportunities for students to collaborate with technology in learning (Gina et al., 2022; Sastradika et al., 2021). It was also discovered that physics experimental activities that aren't supported by appropriate facilities and infrastructure can negatively affect student learning outcomes. (Gonsalves et al., 2016; Gunawan et al., 2018). Therefore, innovation is needed in learning through physics experimental activities.

Innovation in education encourages teaching staff to continue striving to improve their quality by developing quality in the world of education. One form of innovation that continues to be improved in the technology field is the development of learning media. According to (Anwari et al., 2020; Puspitarini & Hanif, 2019), using learning media for the teaching and learning process can increase new interests and desires and stimulate learning motivation. It can even affect the psychological level of students. The more interesting the innovations teachers use to deliver material, the more interested students will be in understanding

teaching and learning in class (Saputra et al., 2018).

Computational physics classification can now solve problems in physics experiments. Students can carry out practical activities using virtual laboratory learning media. The characteristics of a virtual laboratory are that the program contains laboratory equipment that functions like real equipment, students are invited to respond to the virtual laboratory. The computer will respond and provide immediate feedback to students in the form of programmed instructions (Potkonjak et al., 2016). Advantages of using the Virtual Laboratory program in the classroom by allowing students to conduct their laboratory experiments. It should also be noted that the use of the Virtual Laboratory does not mean that it must be used as a substitute for student participation in carrying out practicums in the Physics Laboratory, but only as an alternative to help students easily understand the concept-application material.

One of the virtual laboratory applications that can be used is PhET. PhET (Physics Education Technology) is a simulation developed by the University of Colorado that includes mathematics, physics, biology, and chemistry learning simulations for classroom or individual learning purposes. According to Haryadi and Pujiastuti (2020) the benefits of PhET simulations include emphasizing the relationship between real-life occurrences and the underlying science, supporting participatory and constructivist approaches, providing feedback, and creating a creative workplace.

The rapid development of technology among students, such as gadgets, is not difficult to find to reduce the negative impact of using gadgets such as games among students. According to Kominfo data, smartphones in Indonesia 2018 reached 40% of the population, or around

100 million people (Kominfo, 2019). Based on data from the Badan Pusat Statistik (BPS), 67.88% of Indonesia's population aged five years and over will already have a cell phone or mobile phone in 2022 (Ahdiat, 2023).

Gadgets, especially Android, which are often used as educational systems, can deliver information that can be accessed anywhere. This advantage encourages many teachers to want to integrate it into the learning process. Using applications as learning tools. Students will be told they are not limited by time, meaning they can study during class and extracurricular activities. The use of smartphones by students has a positive impact on the learning environment. Using smartphones as a learning method is a revolutionary way of learning in the 21st century (Adhi et al., 2017; Arista & Kuswanto, 2018; Astra et al., 2015). Supported by research from Lestari et al. (2019) regarding the development of Android-based learning media, it shows that such learning media can increase students' conceptual understanding of a material. Therefore, developing learning media in the form of Android applications is very good and needs to be done.

The development of this learning media is assisted by a website that makes applications without coding called Andromo so that the learning media has an Andromo base. Andromo's advantage is that it provides various features and templates that can be used for free, so developers can create various applications and combine multimedia content in the same application. Developing learning media that emphasizes knowledge of the material, both theoretical and applied, will maximize the physics learning process. Apart from that, learning media applications developed through Andromo can be installed on various versions of Android, from the lowest to

the highest. This convenience will impact the ease with which students can operate learning media as a tool for learning.

Based on the explanation above, researchers are interested in developing Android-based learning media to experiment with High School Students' Optical Equipment material. This research aims to develop Android-based interactive learning media to improve student understanding through experiments on optical equipment materials.

METHOD

This study used a research and development methodology. According to (Sugiyono, 2009), research and development is a process used to generate and test goods. This research resulted in an Android application that concept experts, media experts, instructor empirical tests, and student testing validated. This study is development research that uses the ADDIE approach (Analysis, Design, Development, Implementation, and Evaluation). Figure 1 shows a researcher's flow of thinking using the ADDIE model.

This study uses a one-group pretest-posttest design. The pretest was used to assess students' knowledge before treatment, and the posttest was used to assess students' knowledge following treatment. (Creswell, 2014).

This study's contents comprise material expert lectures, media expert lecturers, physics teachers' class XI Science 1, and class XI Science 1 students from high schools in Bandung. The trial sample was six students in class XI Science 1, and the implementation sample was 28 students in class XI Science 2 at one of Bandung's high schools. These samples were used as research subjects for testing the media being developed and filling out questionnaires to ask for responses to the media testing and implementation.

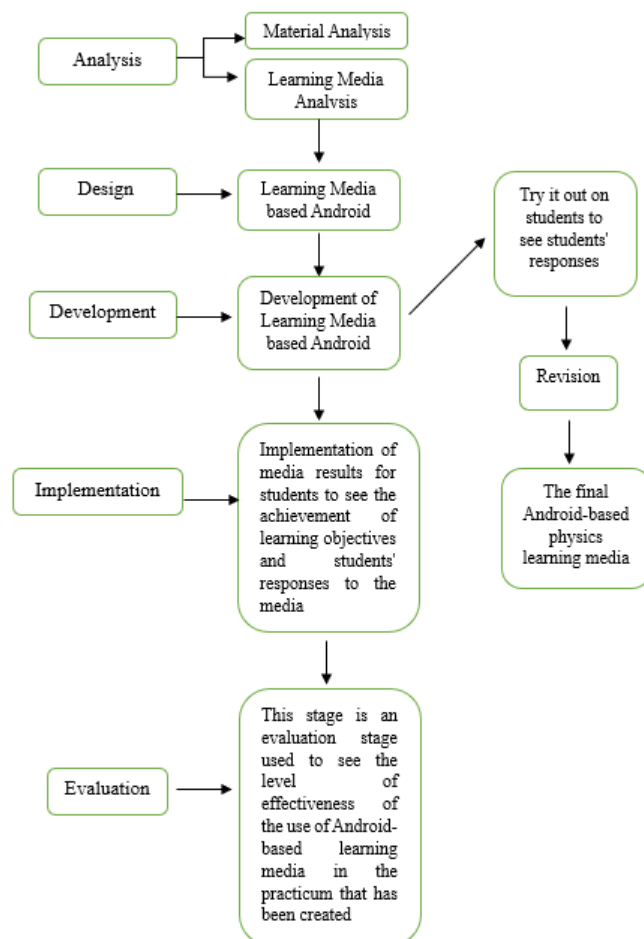


Figure 1 ADDIE research framework

The data from this research shows the effectiveness of learning media. Validation was carried out using the modified questionnaire from the 2014 BSNP and the book “Visual Usability Principles and Practices for Digital Application Design” by Schlatter & Levinson, (2013) with a media expert instructor, a material expert instructor, and a physics expert instructor, carried out by a school teacher. Questionnaires are used to collect student and teacher responses to learning media, identifying

aspects of material, language, attractiveness, ease of use, and understanding.

The implementation is done by providing a media application (Apk) file via WhatsApp. The test used in the pretest and posttest in the form of questions consists of ten questions. Apart from that, students' responses regarding the implementation that has been carried out are also measured by feedback using a four-category Likert scale. The research design diagram is shown in Table 1.

Table 1 Research design diagram

Pre-test	Implementation	Posttest
Pre-test Understanding of optical instrument material	Experimental activities with the developed media	Posttest Understanding of optical instrument material

This research aims to produce a product in the form of Android-based mobile-learning media that can carry out virtual experiments on learning about mirror image formation. Testing the feasibility of the learning media developed for conducting experiments, knowing students' responses to learning media based on Android, and knowing students' understanding regarding experiments using the media developed is quantitative. Hence, the data analysis technique used in this research uses the statistical techniques of the Wilcoxon test and the n-gain test. The Wilcoxon test is used to see the difference between the pretest and posttest, while the n-Gain test is used to see the increase in students' understanding between before and after treatment.

RESULT AND DISCUSSION

The following is a detailed explanation of the research results regarding the creation of Android-based physics learning media in experiments on image formation on mirrors in optical instrument materials carried out using the ADDIE method.

Analysis

The analysis stage carried out is needs analysis, which determines material analysis and learning media analysis. At the needs analysis stage, it was found that limited media, practical equipment, and study time at school made it difficult for students to carry out experiments and understand learning about forming images in mirrors. The teaching and learning activities at the school only use

PowerPoint learning media and explanations from the teacher. So it is hoped that there will be learning media with other innovations to help the learning process in a more interesting atmosphere, especially regarding optical instrument material.

Design

The design stage is the product design stage that follows the results of the analysis carried out previously. The steps in this design stage include:

- In the selection of materials and learning objectives in this research, the materials used are optical instruments in experiment on mirror image formation.
- Learning Media Design Stage
At this stage, the researcher collects materials for media creation needs such as selecting software (the software used is Andromo as the main software for developing learning media), Doratoon is used to create animations in videos, Liveworkshet is used as a student worksheet in learning, QuizWhizzer and WordWall, are used to create interactive learning quizzes and other supporting media such as Canva and PicsArt are used to create images and icons in the media.
- Designing learning media
In this stage, the researcher creates a main page design as a reference for researchers in designing learning media designs so that they are well conceptualized, as in Figure 2.



Figure 2 Learning media design

Development

At this stage, researchers carry out product creation and testing as well as testing practical data from researchers and students. The first step in creating Android-based learning media using Andromo is to register "sign up" via the

Andromo website, namely <https://www.andromo.com/>, then start creating menus according to the design that has been created. The product produced by Andromo is an application (.apk) that can later be accessed on the Android system via an installable file.

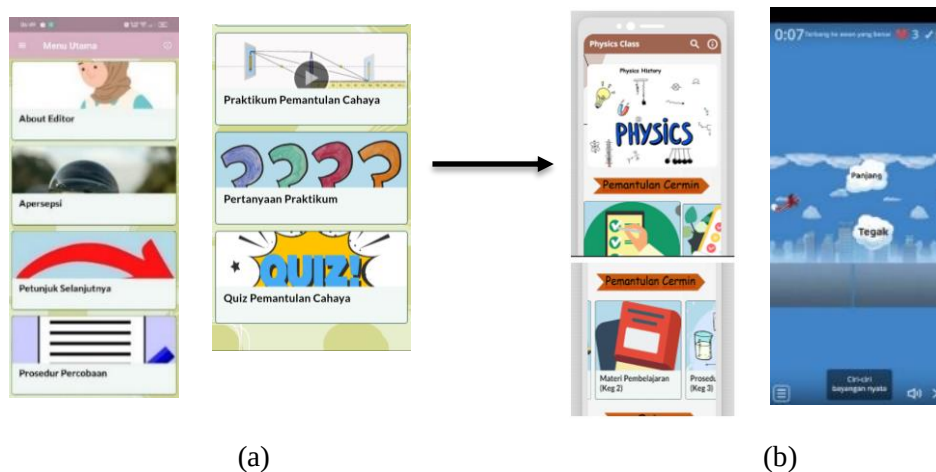


Figure 3 (a) Display of media before revision (b) display of media after revision

After the learning media creation is complete, the next step is to test or validate the product by media expert lecturer and physics teachers, then revise the product development before testing it as in Figure 3.

Media Validation for Learning Media

The results of media validation for learning media by media experts

(validator V_1) and physics teachers (validator V_2) demonstrate that all indicators receive a maximum score of four, except motivational ability, consistency, and imagery. Table 2 shows The results of media validation on learning media by media experts and physics teachers.

Table 2 Results of media validation by media experts and physics teachers

Indicator	Media Experts (V_1)		Physics Teachers (V_2)	
	Total Score	%	Total Score	%
Suitability with the development of students	7	87.50	8	100
Use of terms, symbols	10	83.3	9	75
Straightforwardness	8	100	8	100
Color	8	100	8	100
Typography	11	91.67	12	100
Motivating ability	6	75	8	100
Conformity with Indonesian language rules	7	87.5	7	87.5
Legibility	4	100	4	100
Layout	8	100	8	100
Consistency	15	93.75	14	87.5
Imagery	12	100	12	100
Overall score		92.61		95.45
Criteria	Very Valid		Very Valid	

Material Validation for Learning Media

The results of material validation for learning media by media experts (validator V3) and physics teachers

(validator V2) were very valid. Table 3 shows the results of material validation on learning media by media experts and physics teachers.

Table 3 Results of Material Validation by Media Experts and Physics Teachers

Indicator	Material Experts (V ₃)		Physics Teachers (V ₂)	
	Total Score	%	Total Score	%
Presentation Technique	13	81.25	14	87.5
Material accuracy	7	87.50	8	100
Updating and Contextual	10	83.33	11	91.67
Presentation of Learning	11	91.67	11	91.67
Material coverage	9	75	10	83.33
Material presentation support	8	100	8	100
Overall score		86.46		92.36
Criteria	Very Valid		Very Valid	

Several responses and ideas for improving learning media were obtained based on the findings of validation by media experts, material experts, and physics teachers, respectively. Validator V₁ provides feedback and recommends that, while the learning medium is generally good, the image proportion should be adjusted to reflect the actual size. The V₂ validator, among others, provides useful responses and ideas that can be used to collect data. Validator V₃ claimed that the learning medium was

good and technology-based, although typing required extra attention.

Then, a trial was carried out on students, namely a trial to compare data taken by researchers and data taken by students using virtual experiments on media and students' responses to media trials.

Practical Trial Using Media

The deviation between the terms calculation data and experimental data (1 group consisting of 6 students) is shown in Table 4.

Table 4 Deviation of the terms calculation data and experimental in practicum using media

Mirror	measured data and calculated data	Researcher	Student's	Difference	Percent (%)
flat, concave, convex	Focus point	90 cm	92 cm	2 cm	2.2%
flat, concave, convex	radius of curvature of the mirror	180 cm	184 cm	4 cm	2.2%
Flat	The radius of an object shadow	80 cm	82 cm	2 cm	2.5%
		180 cm	180 cm	0	0%
		200 cm	200 cm	0	0%
		260 cm	260 cm	0	0%
	High object shadow	102 cm	102 cm	0	0%
		102 cm	104 cm	2 cm	1.9%
		102 cm	102 cm	0	0%
		102 cm	102 cm	0	0%
	mirror magnification calculation	1	1.025	0.025	2.5%
		1	1	0	0%

Mirror	measured data and calculated data	Researcher	Student's	Difference	Percent (%)
		1	1	0	0%
		1	1	0	0%

From the table above, it is found that there is no difference in the data obtained and the data calculated between researchers and students in the practice of forming images on mirrors using media.

Student Responses in Media Trial

Student responses can help identify weaknesses or needs for improvement in

learning media. By understanding student responses, developers can make necessary changes, such as replacing less effective images or videos, improving explanations, or adjusting the difficulty level of the material. The results of student responses to the Android-based operating system learning media are shown in Table 5.

Table 5 Recapitulation of students' opinions regarding media in trials

No	Rated aspect	Student's Response				
		Very Good	Good	Enough	Less	Very Less
1.	Media initial display	0%	17%	67%	17%	0%
2.	Ease of accessing media	0%	50%	50%	0%	0%
3.	Suitability of fonts in media	0%	50%	50%	0%	0%
4.	Display of images contained in the media	0%	0%	17%	83%	0%
5.	Language used in the media	0%	67%	33%	0%	0%
6.	Ease of navigation in media operations	0%	50%	50%	0%	0%
7.	Availability and clarity of instructions for using the media	0%	17%	83%	0%	0%
8.	Understanding the material after using the media	0%	0%	100%	0%	0%
9.	Suitability of virtual experiments in media with the objectives of the practical material presented	17%	67%	17%	0%	0%
10.	Suitability of the contents of the LKPD in the media with the practicum material presented	0%	67%	33%	0%	0%
11.	Match the questions in the media with the material presented	0%	33%	67%	0%	0%
12.	Completeness of the material content in the media with the material presented	0%	0%	50%	33%	17%
13.	Suitability of the Quiz to the content of the material in the media presented	0%	33%	67%	0%	0%
14.	Independent learning with the help of media	0%	17%	83%	0%	0%
15.	Interest in learning using media	0%	0%	67%	33%	0%

In the results of trial data on student responses to the media, one respondent, 17%, stated that the completeness of the material content in the media and the material presented was very lacking, then the percentage of respondents 83% stated that the appearance of the images in the media was less attractive, then there was

100% understanding. The material after using the media for practicum purposes, it was sufficient for respondents to understand the material, and 83% of respondents felt that the availability and clarity of instructions for using the media, as well as independent learning using media assistance, were sufficient

for respondents and 67% of respondents stated that the initial appearance of the media and the suitability of the quiz in the media was sufficient. Then, respondents with a percentage of 67%, stated that it was good regarding the language used in the media, the suitability of the virtual experiment in the media with the aim of the practicum material presented, and the suitability of the contents of the worksheet in the media with the practicum material presented. Then, one respondent strongly agreed that the suitability of virtual experiments in media with the aim of the practicum material presented was able to increase students' understanding. IT implementation in a learning field is thought to boost students' learning ability. IT in the learning process will supply learning content in various media, positively improving student learning achievement. Learning with multimedia improves student learning outcomes and comprehension of the topic (Dasilva et al., 2019a; Sari et al., 2017).

From analyzing student responses to the media, respondents provided various comments and suggestions for improvement. One of the suggestions for improvements that researchers will make to the media is to emphasize improving its appearance to make it more attractive and increase students' learning interest in using the media. It is hoped that these improvements can make the media more attractive and engaging for students so that they are more enthusiastic about using it for learning. Apart from that, researchers will also ensure that the material content in the media is available completely and comprehensively. It is important to ensure that all the

information students need in physics practicum is well covered in the media. Thus, it is hoped that this medium can become a more effective tool in supporting practicum in physics learning, helping to increase students' understanding of the concepts being taught and encouraging them to be more active and participate in the teaching and learning process.

Implementation

This implementation activity was carried out to see the effectiveness of media use on students' understanding of optical equipment material in the formation of mirror images. Implementation was carried out by distributing learning media to 28 class XI Science 2 students at one of the State High Schools in Bandung. After making improvements from the trials that have been carried out, the results are improvements to the media appearance and additional features. The implementation of the experiment on forming an image in a mirror consisted of 5 groups, each group comprising 6 people. After experimenting, each group was asked to answer a worksheet consisting of 7 essay questions with indicators for each question, namely the students' ability to explain the principle of shadow formation, the student's ability to identify the type of shadow formed, the student's ability to differentiate between the properties of shadows, the student's ability to calculate the position and size of the image formed, as well as the student's ability to apply the concepts of image formation in flat, concave, and convex mirrors. The results of the LKS analysis for each group can be seen in Table 6.

Table 6 Worksheet's answers for each group

Group	Student's Answer							%	Category
	1	2	3	4	5	6	7		
Group1	4	4	4	4	4	4	4	100	Very Good
Group2	4	4	3	3	4	4	3	89.29	Very Good
Group3	4	3	4	4	2	3	4	85.71	Very Good
Group4	4	3	3	3	3	3	2	75	Good

Group	Student's Answer							%	Category
	1	2	3	4	5	6	7		
Group5	0	0	0	0	0	0	0	0	Less
%	80	70	70	70	65	70	65		
Category	Very Good	Good	Good	Good	Good	Good	Good		

Based on Table 4, it was found that the assessment of each group's Worksheet's answers stated that in groups 1, 2, and 3, the group's answers were very good, and group 5 said it was poor because they did not provide the results of their

Worksheet's answers. Then, the group answered each question: only the first question said it was good, and the next question said it was good. This proves that the students in the group can answer the Worksheet very well.

Table 7 Student pretest-posttest difference test results using the Wilcoxon test

		N	Mean Rank	Sum of Ranks
Posttest - Pre-Test	Negative Ranks	2 ^a	7.00	14.00
	Positive Ranks	23 ^b	13.52	311.00
	Ties	3 ^c		
	Total	28		
Z			-4.026 ^b	
Asymp. Sig (2 Tailed)			.000	
Wilcoxon Signed Rank Test				
Based on negative ranks				

Analysis of Student Understanding

Apart from being reviewed based on response questionnaire data, effectiveness was also reviewed based on comprehension tests after conducting experiments using Android-based learning media. Analysis of student understanding uses two tests, namely the Wilcoxon Test, to show differences in students' pretest and posttest. And n-gain test to see student understanding. The analysis results of student understanding can be seen in Table 7 and Figure 4.

Based on Figure 4 of the results of the student understanding test using the N-Gain test, it was found that 14 students had high understanding, nine medium, and seven students after conducting experiments using media with low criteria. After being analyzed, 3 of them were students who did not provide Worksheet answers. Next, interviews will be conducted with seven students in the low category.

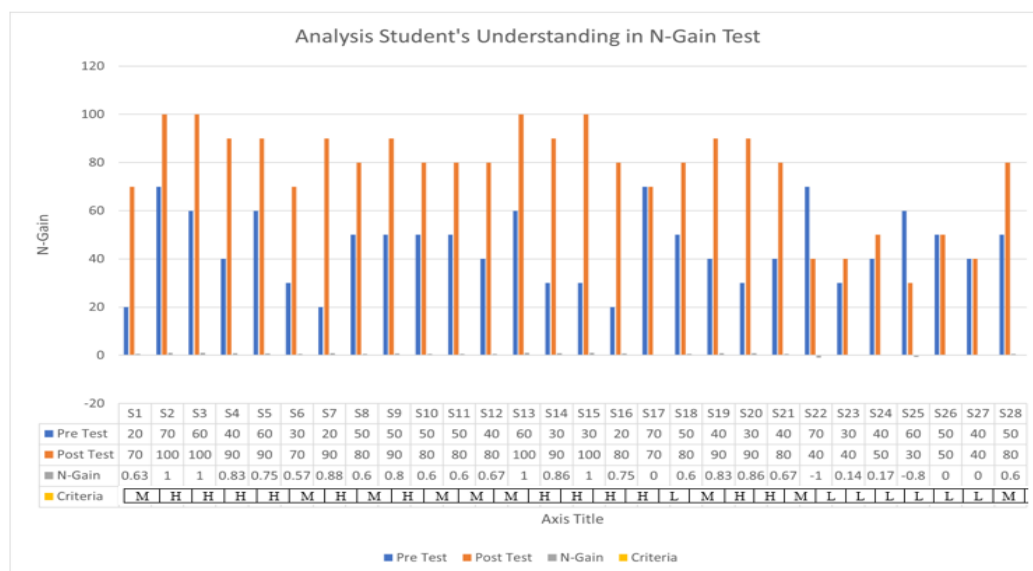


Figure 4 Student comprehension test results using the n-gain test

Further testing reveals that students who use the ThinknLearn program recall information/material more effectively than students who do not use the ThinknLearn application (Ahmed & Parsons, 2013). According to another study (Maknun, 2020; Srisawasdi & School, 2014), students' conceptual knowledge can be improved and sustained for up to two months after learning through open inquiry-based mobile learning simulations. Improving

student's scientific understanding is one method of improving higher-order thinking skills (Dasilva et al., 2019b). Students also state that Physics Mobile Learning Media helped them understand physics concepts.

Analysis of Student Responses Regarding Media

Table 8 shows the results of student responses to the Android-based operating system learning media, which has made improvements.

Table 8 Recapitulation of students' opinions regarding media after improvement

Rated Aspect	Student Responses			
	Strongly Agree	Agree	Less Agree	Disagree
I am interested in learning physics using this Android-based media.	25%	75%	0%	0%
I can follow the lesson well by doing practical work on forming images in a mirror using this media	11%	89%	0%	0%
After using this media in doing practicums, I understand the material of optical instruments in the formation of images in mirrors	0%	93%	7%	0%
Retrieving data in practicums using this media is quite easy	7%	93%	0%	0%
After doing a practicum using this media, I was able to solve problems from the LKPD	0%	96%	4%	0%
I am interested in learning physics using this media because it has learning quizzes that are packaged in an interesting way	46%	54%	0%	0%

Rated Aspect	Student Responses			
	Strongly Agree	Agree	Less Agree	Disagree
I can understand learning using this media because it provides many material sources	43%	57%	0%	0%
I am interested in this media because it can be accessed at a more flexible time	64%	36%	0%	0%
I am interested in studying physics using this media because it has an attractive and colorful appearance	64%	36%	0%	0%
I feel the media developed is easy to use	61%	39%	0%	0%

Two of the total respondents, with a percentage of 7%, stated that they disagreed that after using this media in practicum, students understood the materials of optical instruments in the formation of mirror images. Then there was one respondent who did not agree that after doing a practicum using media, students could solve problems from the Worksheet given. The response results are relevant to students in the group who answered the Worksheets, but the n-gain results are low.

Evaluation

Table 9 Student interview results

Respondent	Respondents Criteria	Respondents Answer
Respondent 1	Has a very good Worksheet score has a Low N-Gain Test score	- Learning physics is difficult for me because it has many formulas, and it is difficult for me to understand; if I miss one material, I can no longer follow it
		- The media is interesting, only the features are more solidified
		- The features are more solidified and also available for iOS devices, so they can be used by everyone
		- No difficulty using it. The difficulty is if the cellphone network has problems
		- In experimenting, I was only active in collecting data, not in answering the Worksheet
		- Hmm.. because I don't know the answer.
		- I can answer some questions by doing practical work, but I don't know how to calculate and use formulas.
		- For me, no, because the material and experiments are complete; maybe you can explain it again to me.

From the results of interviews with three students who had low n-gain scores and group scores, it was found that

This stage is an evaluation stage used to see the effectiveness of using Android-based learning media in the practicum that has been created. Effectiveness can be seen from the interviews with students who received low criteria on the n-gain test and comments and suggestions from student responses regarding media.

Student's Interviews

Table 9 below shows the interview results of 3 selected students with low n-gain scores, and the group practicum results were not good.

students had difficulty learning physics from the start, the questions in the media

were unclear, and the tools for using the media were limited.

Student Responses Regarding Media

From the analysis of student responses to the media, respondents provided comments and suggestions for improvements that researchers would make to the media, namely to improve the media being developed by adding several interesting features such as background sound to quizzes, adding material, adding interactive quizzes and making it possible for the media to be accessed. Not only for Android but it can be used for iOS devices. Researchers use the results of these suggestions, opinions, and input to revise the products being developed.

CONCLUSION

Based on the research results, it was concluded that the use of the media developed had a significant influence and improvement on student learning outcomes. Apart from that, learning activities on optical instruments using developed media provide positive experiences for students.

This research has limitations, namely the use of a small sample. So, further tests on a larger scale are needed to see the effectiveness of media use on students' understanding. Apart from that, learning media must also be associated with various models and approaches to determine its effectiveness.

Based on research that has been conducted, this learning media has the advantage of being accessed easily anywhere and at any time. The media is presented with an attractive packaging design, and there are materials, learning videos, virtual practicums, and interactive quizzes. However, this learning media also has drawbacks, namely that it cannot be accessed using IOS and has limited permissions for several other virtual experiments. This makes improvements for other

researchers an opportunity to develop this media.

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