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Development Of Physics Learning Media PHY-ART (Physics With Augmented Reality Technology) To Empower Student's Laboratory Skills

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ABSTRACT
The world of education requires newest learning media when technology is growing. The development of Physics learning media with Augmented Reality technology is a solution to bring forward education. The development of Physics learning media PHY-ART aims to describe the development of Augmented Reality technology for physics learning media, and find out the impact of implementing Physics learning media PHY-ART on improving students' laboratory skills. A total of 78 high school students were researched with pre-test and post-test to determine the students' laboratory skills before and after. After using Physics learning media PHY-ART, it is known that AR technology improves students' laboratory skills. The physics learning media PHY-ART can be used by educational practitioners to improve laboratory skills and can be used as an alternative in the variety of learning media.

INTRODUCTION

The interest of Augmented Reality (AR) in an education context is highlighted by several authors : According to Fjeld [1], learning by doing and in situation allows to build knowledge in an active and autonomous way. Cieutat indicate that in the case of practical work, the systems using AR can bring a "semideterminist" aspect where everything is not foreseen beforehand and for which technology is easy to put in place [2]. AR also allows to see as real, object with which the user interacts : this strong feeling of "presence" improves memorization [3]. Moreover, AR changes the way users and machines interact, which can lead the students to tackle the lesson topics in a different and more pro-active way [4]. The most common use of AR in education concerns interactive lessons offering 3D visualizations, this allows teachers to reduce the gap between real and virtual. The implementation of physics learning is not only carried out in the classroom, but also in the laboratory. Laboratory skills need to be possessed by students in conducting experiments. The importance of laboratory skills is emphasized by Watson [5] that the laboratory skills approach provides direct, first-hand experience to students, so as to be able to change students' perceptions of important things.

Augmented Reality is a situation where the real world context is dynamic with coherent placement or context sensitive virtual information [6]. This three-dimensional Augmented Reality display is in the form of a virtual image superimposed on the real environment accurately [7]. Milgram & Khisimo [8] define AR as a technique which converts computer graphics from images or videos into real events. AR has three main characteristics, namely, the combination of virtual and real objects in real settings, people working interactively at the same time, boundaries between real objects and virtual objects [9]. AR was first used in the 1990s, when it was applied to pilot training [10].

Laboratory skills are classified according to the Swedish national standard developed by Grelsson and Ottander in 2005. This classification was developed after an analysis of the literature based on an assessment of laboratory practice and a theoretical assessment process [11]. There are five assessment criteria: planning the experiment, carrying out experiment, interpretation of results, evaluation of results, and presentation [11]. Assessment criteria can be described through different skills that need to be assessed against standards as shown in Table 1. The importance of laboratory skills is provide live experience, first-hand experience to students, so they are able to change perceptions of important things [5].

Table 1. Skills possible to assess laboratory excercises

Five Assessment Criteria	**Skills possible to assess**	
Planning experiments	Hypothesis/prediction Define variables Design procedure & experiment	Studies of literature Theories/ideas Choice of methods
Carrying out experiments	Use of instructions Measure Choice/use of equipment	Collection/documentation of Maintain order Observe safety procedures
Interpretation of results	Analysis of results Interpretation of results	Analysis of limitations Analysis of assumptions
Evaluation of results	Evaluation of results Evaluation of methods Evaluation of sources of error	Evaluation of limitations & assumptions Evaluation of conclusions
Presentation (report or performance)	Description of questions/hypothesis Description of methods Description of results	Discussion Conclusions Synthesis

The development of Physics learning media PHY-ART aims to describe the development of AR technology for physics learning media, and find out the impact of implementing Physics learning media PHY-ART on improving students' laboratory skills.

METHOD

The development of the PHY-ART learning media uses RnD with the adapted Borg and Gall model. Then the product is validated before being tested in the field based on content, language, and media experts. This product validation consists of 40 questions with a score range of 1 to 5. Table 2 shows the assessment of the product and its category.

The participants in this study were grade 11 students (aged 16-17 years) from 3 city schools. Participants consisted of 78 students with 16 males and 62 females. Participants were given a pre-test to measure laboratory skills before doing the intervention. After that, an Android application that carries Augmented Reality technology was introduced in order to empower students' laboratory skills. Then the students conducted a light refraction experiment that aim to determine the refractive index of the prism. After that, a post-test was given to determine the laboratory skills afterwards.

Table 2. Assessment Criteria in the Validation stage

Score Interval	Criteria
160 < score	Very Good
133,33 < score ≤ 160	Good
106,67 < score ≤ 133,33	Moderate
80 < score ≤ 106,67	Less
score ≤ 80	Very Less

Table 3. Pre-test and Post-test

	Quistionnaires
1	I'm capable to formulate hypotheses that can be tested based on experimental results
2	I'm capable to determine the variables related to the experiment
3	I'm capable to do a literature study related to the experiment
4	I'm capable bring up a theory or idea related to the experiment
5	I'm capable to develop experiment designs that can prove the hypothesis
6	I'm capable to make work plans made in flow charts and equipped with observation tables
7	I'm capable to make a complete method, starting from the preparation of the experiment, perfomance f the practicum and after the experiment
8	I'm capable to carry out experiment corresponding with the order of the procedure
9	I'm capable to choose experiment and materials to experiment wisely
10	I'm capable to collect data completely and accurately
11	I'm capable to carry out experiments coherently
12	I'm capable to use laboratorium safety equipment during experiment
13	I'm able to analyze the result data of the experiment properly
14	I'm capable to interpret experiment data
15	I'm capable to analyze the limitations of the experiment precisely
16	I'm capable to analyze the assumptions of errors in conducting experiments
17	I'm capable to evaluate the experiment result
18	I'm capable to evaluate the experiment methods that have been carried out
19	I"m capable to evaluate the source of the error during the experiment
20	I'm capable to evaluate the limitations and assumptions of the experiment
21	I'm capable to evaluate the conclusions of the experiment
22	I'm capable to describe hypotheses accurately based on previous evaluations
23	I'm capable to describe the method accurately based on previous evaluations
24	I'm capable to describe the experiment results clearly in descriptive form
25	I'm capable to discuss the results of the experiments with other group of discussion
26	I'm capable to make conclusions that can answer the formulation of the problem and prove the hypothesis made correctly
27	I'm capable to correlate the results of experiments that have been carried out with the concepts of physics in daily life

In determining the category of students' laboratory skills, based on Table 4 below. Then in analyzing the pretest and posttest data, the n-gain test was used as proposed by Hake [12] with categories as shown in Table 5.

Table 4. Category of Student Laboratory's Skills

Grade Range	Value Category
3,33 < score < 4,00	Very Good
2,33 < score ≤ 3,33	Good
1,33 < score ≤ 2,33	Enough
score ≤ 1,33	Less

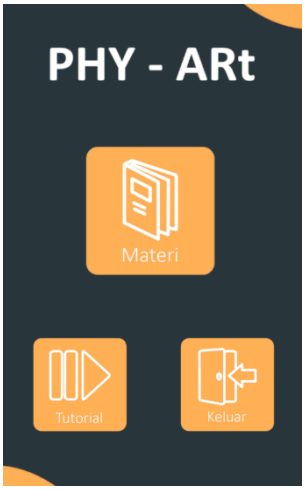
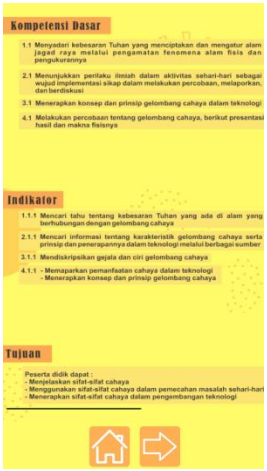
Table 5. N-gain score criteria

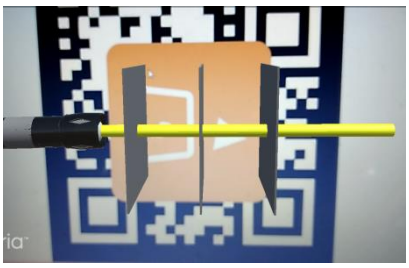
N-Gain score	Criteria
(g) ≥ 0,7	High
0,7 > (g) ≥ 0,3	Moderate
(g) < 0,3	Low

RESULTS AND DISCUSSIONS

The display of the PHY-ART Physics learning media using Augmented Reality technology in order to empower laboratory skills is as shown in Table 6. Augmented Reality results in the form of 3D will appear after the device scans the barcode that has been prepared.

Table 6. Media Layout

Media section	Media Design	Media Section	Media Design
Cover		Menu	
Tutorial		Preface	

Result of Augmented Reality		Result of Augmented Reality	

On the cover there are three menus, namely "Material", "Tutorial" and "Exit". In the "Material" menu, there are sub menus "Straight Propagation", "Dispertion", "Polarization", "Reflection", "Refraction", and "Difraction", which lead to Augmented Reality technology. In the "Tutorial" menu, there is an application manual book that can be downloaded, while the "Exit" menu is to close the application.
Media then validated before being implemented through 6 validation experts, with 2 experts on content aspects, 2 experts on language aspects, and 2 experts on media aspects. The results of expert validation are shown in Table 7 below:

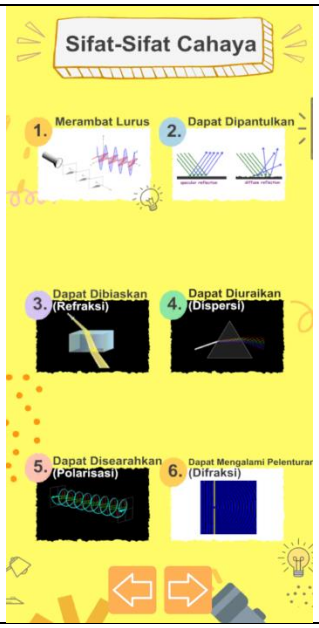
Table 7. Expert Validation Results

Aspects Considered	Average score Aspect	Validity score	Rate Validity
Contents	51	178	Very Good
Language	46,5		
Media	80,5		

The results of expert validation can be expalined that : the average score of contents aspect is 51, the average score of language aspect is 46,5; the average score of media aspect is 80,5. According to the data, the validity score is 178 which means the physics learning media PHY-ART is declared valid. The suggestions and revision from experts can be seen in Table 8 below :

Table 8. The suggestions and revision

Suggestions	Before revision	After revision
The placement of the "Pendahuluan" font is deformed and the font size is too small		
The subject material should not be separated from the AR media, so that it is combined with the media to make it easier to integrate		

Improve the User Interface (UI) display media.		

The next stage is user validations by user with 3 physics subject teacher and 78 student. The results of user validation described in Table 9.

Table 9. User Validation Results

User	Aspects Considered	Average score Aspect	Validity score	Rate Validity
Physics subject teacher	Contents	59,3	185,9	Very Good
	Language	47		
	Media	79,6		
Students	Contents	16,9	103,8	Very Good
	Language	16,6		
	Media	41,5		
	Utilization	28,9		

The results of user validation spesifically physics subject teacher can be explained : the average score of contents aspect is 59,3; the average score of language aspect is 47; the average score of media aspect is 79,5. Then the results of user validation spesifically students can be explained : the average score of contents aspect is 16,9; the average score of language aspect is 16,6; the average score of media aspect is 41,5; and the average score of utilization aspect is 28,9. Based on these two data, the validity score are 185,9 and 103,8; which means the physics learning media PHY-ART is declared valid.

After being declared valid by experts and users, the effectiveness of the physics learning media PHY-ART was tested. The effectiveness test using the n-gain score, the results of the pretest and posttest before and after being treated with AR technology are as shown in Table 10, then the results show an increase in students' laboratory skills scores as shown in Table 11.

Table 10. N-gain score test results

Components	Pretest	Posttest	N-Gain	Categories
The highest score	80	100	0,56	Moderate
Lowest score	10	70		
Average	50	80		

Table 11. Laboratory skills score

Criteria	Before	After
Planning experiments	1,81	2,78
Carrying out experiments	2,07	3,29
Interpretation of results	2,07	3,10
Evaluation of results	2,04	3,13
Presentation (report or performance)	2,19	3,24

From table 10 it can be seen that the n-gain score is 0.56, it shows that the physics learning media PHY-ART is effective in improving student laboratory skills. This is reinforced by the data on laboratory skills scores in table 11 where all of the criteria have increased.

CONCLUSION AND SUGGESTION

Based on the research that has been done, the development of physics learning media PHY-ART at the validation stage from the expert obtain score 178, which means the product has very good criteria. Then from user validation for teachers with a score of 185.9 and students with a score of 103.8, means that the product has very good criteria. Furthermore, in the effectiveness test stage, a score of 0.56 was obtained, which means this product is effectively used to improve laboratory skills. It can be seen that the students' laboratory skills increase from before and after, it shows that the PHY-ART Physics learning media improves laboratory skills. The physics learning media PHY-ART can be used by educational practitioners to improve laboratory skills. In its application to the teaching and learning activities, this physics learning media PHY-ART can be used as an alternative.

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