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Developing a Virtual Laboratory-Based Experiment Module on Millikan's Oil Drop Materials

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ABSTRACT

The purpose of this study was to determine the design of the experimental module based on a virtual laboratory, to determine the feasibility of the product developed as a learning resource for students of Physics Education at the University of Muhammadiyah Metro, to determine the user's response to the developed product tool. The development of this product can facilitate students in learning and as a learning supplement for educators in classroom teaching activities. The product developed is an experimental module based on a virtual laboratory which is used to make it easier to understand the material of your oil drops. This research method uses the R&D (Research and development) method and uses the ADDIE model. The data collection instrument used observation and interviews. From the results of observations and interviews, researchers used to make it easier to draw conclusions. Based on the results of the analysis that the results of expert validation resulted in an average of 84.75% with a very suitable category for use and student responses producing an average response of 90.51% and in the very interesting category.

Keywords: *Development, Experiment Module, Oil Drops Owned.*

INTRODUCTION

Education is the process of transferring knowledge, understanding, and appreciation. Education is one of the efforts or ways to education a nation's future generations to conceive knowledge and technology and skills that might prepare them to live among the society (Arwudarachman, et al., 2015). Education is a crucial thing, education also creates knowledgeable and broad-minded generations with the help of technological growth (Arwudarachman, et al., 2015; Yaumi, 2018; Aththibby, et al, 2022). Learning is an interaction process of students with teachers and learning sources in a learning environment. Learning is a support given by educators to create a process of knowledge acquisition, mastery of skills and characters, and an establishment of attitude and trust in students. Learning activities are arranged to help individuals to have capabilities and competencies deliberately designed to facilitate the course of active and efficient learning process in students (Pribadi in Hadi, 2016).

Physics is one of the branches of science or natural science which studies about natural phenomena using scientific methods acquired from studies or outcome of thoughts. Teaching materials are a set of learning materials based on the curriculum used in an effort to achieve the pre-determined standard of basic competencies (Lestari, 2013). Teaching materials which are designed comprehensively- in the sense that there are elements of media and adequate teaching materials-will affect the learning atmosphere, causing the ongoing learning process in students to be more

optimal. In principle, module is a teaching material arranged systematically with a language that is easy to understand by students in accordance with their ages and levels of knowledge, so they can learn independently with a minimum support or guidance from teachers (Prastowo, 2015). Module is a self-instructional learning material which only contains one learning subject. Module might create a learning process to be more interesting, more interactive, and capable of giving messages in a learning material, can be in the form of facts, concepts, and procedures.

The utilization of media is aimed to motivate students. The media used must have requirements and criteria to be compatible with the learning purposes. Learning media are media used frequently during the learning process as the conveyor of messages between teachers and students to achieve teaching purposes(Mais, 2018). Virtual laboratory can de defined as a laboratory that might embody abstract concepts into visualization with the support of technology. Substantiated by the statement of (Rosdiana, et al., 2019), it is stated that virtual laboratory allows students to learn comfortably because the instruments and materials are simulated into a computer to make them less dangerous. The calculation results of experiment data that use virtual laboratory are more valid and proper, therefore, it will be easier to understand the presented concepts.

LITERATURE REVIEW

The development of a research-based product is divided into five main stages, namely need analysis of product development, designing the product feasibility, product implementation or the creation of product in accordance with the designing result, product testing or evaluation, and continuous revision (Mulyatiningsih, 2014). Development is the steps to develop a product or complete the existing one, which is aimed to produce a product through development processes and changes to complete the product. Saputro (2017:9) concluded that research and development (R&D) method is a research method used to produce a specific product, and test the effectiveness of such a product. Yunus and Alam (2015) expressed that teaching materials are used to deliver learning purposes, improve learning motivation, anticipate learning difficulty, provide exercise, provide summary and centred on independent learning activities arranged in an integrated manner. Teaching materials are used by teachers to deliver learning subjects, teaching materials consist of various kinds (Kurniawati, 2015). Teaching materials that are used by teachers to deliver learning subjects include print and non print teaching materials (Awalludin, 2017).

Learning module is a teaching material which is appealing and arranged in an integrated manner, containing materials, method, and assessments studied by students to improve their capabilities (Syafri, 2018). Module is the smallest unit that operates independently. Based on that understanding, learning activities can be done without the presence of a teacher (Yaumi, 2018). Students can learn independently by using a module (Nurdiansya and Mutuala'liah, 2018). According to Daryono (2014), to produce a module capable of improving learning motivation, the module development must address characteristics required as a module. Module characteristics are described as follows.

1. Self Instructional, a module can be used by students to learn independently and irrespective of other parties, i.e., learning by using a module.
2. Self Contained, all required learning materials are contained in the module. The purpose of this concept is stand alone.
3. Stand alone, is a characteristic of a module that is not depending on other teaching materials/media, or does not have to be used correspondingly with other teaching materials/media. By using a module, students do not require

other media/teaching materials to study and complete the assignments within the module.

4. Adaptive, a module should conceive a high adaptability towards the development of science and technology. A module is defined as adaptive if it can adapt to the development of science and technology as well as flexible to be used in various hardware.
5. User Friendly, a module should fulfil the user friendly principle or familiar to use by the users. It should not be used merely as a handbook, but rather works as a guidance and learning book that must be studied.

Prastowo (2015:221) expressed that a module is a complete unified program, thus, it can be studied by students individually. As an independent learning material, this learning material is packed in such a way so students can learn independently through a module without being limited by time, interest, and other aspects external to themselves. A good and proper module is a module with character which allows students to learn independently without depending on teachers. The presented materials are in sequence; therefore, students can learn thoroughly and study materials or do assignments without using other media.

Experiment is a program with planned designs aimed to test hypotheses derived from theories (Firman, 2017). Learning that uses experiment method is a part of the entire process of teaching in class, open process and active role of students. Experiment is useful to prove a theory. In addition, experiment is useful to develop exploratory attitude concerning science and technology- an attitude of a scientist (Sagala, 2012). Experiment also has superiorities, one of which is making students to be accustomed with using scientific methods to face all problems, therefore, they do not believe easily on something in which the truth is uncertain (Roestiyah, 2012).

Learning medium is anything that can deliver messages, stimulate thoughts, feelings and will of student, thus, encouraging the embodiment of learning process in students. The basic consideration in selecting media is very simple, i.e., capable of fulfilling the needs or achieving the desired or undesired purposes (Sadiman, 2014). A learning medium can be used to create an actual learning condition. Media are functioned to connect information from one party to another. Duludu (2017:9) concluded that a learning medium is a medium used by teachers to deliver messages or information to their students, causing the students to get stimulated when following learning activities. A learning medium is an instrument used by teachers to educate and attract students to participate in a learning. A learning medium is inseparable part of teaching and learning process for the sake of achieving general goals and learning goals in accordance with the development of technology.

There are seven criteria that must be addressed by teachers in using media, namely the media used must be consistent with learning goals, the media used must be compatible with the characteristics of learning materials, the learning media must be based on student's condition, teacher's capability in using media, the media used can improve student's learning motivation, the media used are varied and innovative, and the media used should be contextual or familiar for the audiences (students) (Darmadi, 2017:91). Some aspects that must be considered in choosing media include the support towards the contents within learning materials- meaning that learning materials that speak about facts, principles, concepts, and generalizations highly require media to be more understandable for students; the easiness in obtaining the media used, the skill of teachers in using it, the availability of time in using it, and the compatibility with the thinking level of students (Sudayana, 2015:17).

A virtual laboratory is a learning experience that simulates authentic laboratory, the laboratory is simulated in digital format, so it can be used by students to explore concepts and theories (Wibawanto, 2020). Similar to Riswanto et al. (2018) who stated that a virtual laboratory can be defined as a series of computer programs that can visualize abstract phenomena or complex experiments of the actual laboratories, so it can improve learning activities in an effort to develop the required skills in solving problems. A virtual laboratory or often referred to as a virtual lab is a series of laboratory tools in the form of interactive multimedia-based computer software, which is operated by a computer and can simulate activities in the laboratory as if the user is in a real laboratory (Wahyuni et al, 2020).

MATERIALS & METHODS

This development used ADDIE development model because ADDIE model consists of five components. One of the functions of ADDIE is as a guideline in building an instrument and infrastructure of a training program that is effective, dynamic, and supporting the training's performance itself. This model consists of five steps, namely (1) analysing, (2) designing, (3) developing,(4) implementing, and (5) evaluating.

The steps of ADDIE development model are:

1. Analysis, related to the analysis on work situation and environment, so a product that needs to be developed can be found.
2. Design, designing the product according to needs.
3. Development, creating and testing the product.
4. Implementation, the activity of using the product.
5. Evaluation, the activity of assessing if every step and the created product have matched the specifications.

The data collecting instruments used in this study of developing web application-based e-module were expert validation questionnaire, student response questionnaire, learning motivation questionnaire, and student learning outcome questionnaire. The data analysis technique used in the study was an analysis technique related to the aim of this study, therefore, the data analysis was performed on the media's design, the media's feasibility, and the media's effectiveness on learning motivation of student to facilitate the researchers in understanding the data and drawing conclusions. The percentage of each sub variable was calculated by using the following formula:

$$Percentage = \frac{\Sigma \text{ score given by validators}}{\Sigma \text{ maximum score}} x100\%$$

RESULT

This development produces a learning medium in the form of an experiment module based on virtual laboratory on Milikan's oil drop material.

The creation of a virtual laboratory-based experiment module

The creation of a virtual laboratory-based experiment module on Milikan's oil drop materials was based on the previous stage. The following is the result of module designing that has been designed according to its part.

1) Cover part

Figure 2. Module's Cover

2) Introduction

Figure 3. Introduction

After all components were finished, the next step was printing the module.

The feasibility test of the virtual laboratory-based experiment module

The validation was conducted after the creation of a virtual laboratory-based module experiment has been completely developed. The validators of the virtual laboratory-based experiment module consisted of three lecturers of physics education of Universitas Muhammadiyah Metro.

Table 1. The recapitulation result of validation by three media experts

No	Aspect	Score acquisition	Percentage (%)	Category
1	Module size	11	73.33 %	Feasible
2	Cover design	91	86.66 %	Very feasible
3	Module content design	117	90.76 %	Very feasible
Mean		73	83.58 %	Very feasible

According to Table 1, it is explained that the assessment by media experts that has been done on the aspect of module size obtains a percentage value of 73.33%, the cover design aspect obtains a percentage value of 86.66%, the module content design aspect obtains a percentage value of 90.76%, so the mean value for media experts is 83.58% that falls in a very feasible category.

Table 2. The recapitulation result of validation by three media experts

No	Aspect	Score acquisition	Percentage (%)	Category
1	Content feasibility	124	82.66 %	Very feasible
2	Presentation feasibility	78	86.66 %	Very feasible
3	Language feasibility	78	86.66 %	Very feasible
Mean		93,33	85.32 %	Very feasible

Based on Table 2, it is explained that the assessment done by the material experts that has been carried out on the content feasibility aspect obtains a percentage value of 82.66%, while the presentation feasibility aspect obtains a percentage value of 86.66% and the language feasibility obtains a percentage value of 86.66%. Therefore, the mean value of material experts is 85.32% that falls in a very feasible category. From the calculation results of the experts, the product of the virtual laboratory-based experimental module is very feasible to be used and tested on students.

The implementation stage was the virtual laboratory-based experimental module which has been completely developed and then implemented for Physics Education students at Universitas Muhammadiyah Metro. The implementation of this media test was conducted in a class of 12 students when the learning began. After the learning was complete, students were asked to fill out a respondent questionnaire containing 18 questions to provide responses to the virtual laboratory-based experimental module.

Table 3. The recapitulation of students' responses

No	Aspect	Score Acquisition	Percentage (%)	Category
1	Display	291	97.00%	Very appealing
2	Material presentation	375	89.28%	Very appealing
3	Benefit	307	85.27%	Very appealing
Mean		324.33	90.51%	Very appealing

Based on Table 3, the responses of students to discover the attractiveness of the virtual laboratory-based experimental module on Milikan's oil drop materials are described in which the display aspect obtains a percentage value of 97.00%, the material presentation obtains a percentage value of 89.28% while the benefit aspect obtains a percentage value of 85.27%. Therefore, the mean value of the three aspects can be

obtained which is 90.51% that falls in very appealing category.

DISCUSSION

This study and development of a virtual laboratory-based experiment model on Milikan's oil drop materials was conducted with a large scale at Universitas Muhammadiyah Metro with 12 students as the respondents because it was no longer restrained by the Covid-19. This development study used the ADDIE research that underwent five stages, namely analyse, design, development, implementation, and evaluation. Riswanto et al., explained that a virtual laboratory can be defined as a series of computer programs that can visualize abstract phenomena or complex experiments of the actual laboratories, so it can improve learning activities in an effort to develop the required skills in solving problems. A virtual laboratory-based experiment module was designed to provide an easy understanding towards students and can also be used by lecturers as a teaching medium. The virtual laboratory-based experiment model contains materials of Milikan's oil drop definition, the discovery of Milikan's oil drop, work principles of Milikan's oil drop, energies that affect Milikan's oil drop, and practicing of Milikan's oil drop with virtual laboratory. This module contains evaluations equipped with answer key to facilitate lecturers in correcting the assignment results of students.

This developed product has undergone several development stages that determine the product's feasibility. The results indicated that the product of virtual laboratory-based experiment module is very feasible to be used in improving comprehensions of students. This condition is substantiated by the assessment results of experts and students. The assessment results of feasibility and attractiveness of the module can be seen in Table 4.

Table 4. The expert validation results and responses of students

	Expert validation (materials and media)	**Responses of students**	**Conclusion**
Mean	84.75 %	90.51 %	The virtual laboratory-based experiment module on Milikan's oil drop materials is very feasible and appealing to be used as a teaching material.
Category	Very feasible	Very appealing	

According to Table 19, the validation assessments from material experts and media experts acquire a mean percentage of 84.75% that falls in very feasible category, meanwhile, responses of students acquire a mean percentage of 90.51% that falls in very appealing category. Therefore, it can be concluded that the virtual laboratory-based experiment module on Milikan's oil drop materials is very feasible and appealing to be used as a teaching material in learning.

The results acquired from the testing/trial of the virtual laboratory-based experiment module indicated that students were capable of acquiring better scores to the prior. Before using the virtual laboratory-based experiment module, the filling out of the questionnaire regarding student career comprehension resulted in below average scores. After the students used the virtual laboratory-based experiment module, the acquired scores increased compared to the previous scores. The application of the virtual laboratory-based experiment model in Universitas Muhammadiyah Metro aimed to help students in understanding the materials has resulted in a very feasible module to be used. This condition is substantiated by the data attached by the researchers.

According to these data, it can be concluded that the final product of this development study is a virtual laboratory-based experiment module that is very feasible to be used in improving student's comprehension. The accumulation results of experts and students showed a score of 85.32% for material experts and a score of 83.58% for media experts, meaning that the validity criteria of a feasible product were fulfilled. Students generate a score of 90.51%, which means that the validity

criteria of a very appealing product were met. The results obtained from the experts and students were accumulated, therefore, a score of 87.64% was acquired which indicated that the validity criteria of a very feasible product were fulfilled. Based on the data shown above, this virtual laboratory-based experiment module is very feasible to use, and the effectiveness can be seen in Table 5.

Table 5. The answer score results before and after the module is used

No	Name	Number of Correct Answers		Score	
		Before	After	Before	After
1	Sample 1	2	10	20	100
2	Sample 2	3	8	30	80
3	Sample 3	3	8	30	80
4	Sample 4	4	9	40	90
5	Sample 5	5	9	50	90
6	Sample 6	4	7	40	70
7	Sample 7	6	8	60	80
8	Sample 8	5	7	50	70
9	Sample 9	4	9	40	90
10	Sample 10	3	8	30	80
11	Sample 11	8	9	80	90
12	Sample 12	7	9	70	90
Mean		4.5	8.41	45	84.16

According to these data, it can be concluded that this visual laboratory-based experiment module is effective to be used considering the improvement of scores before and after the module was used. The mean score before the use of the module reached 45 while the mean score after the use of the module reached 84.16. It can be interpreted that the increased score shows the effective use of this virtual laboratory-based experiment module and its capability to help improving the comprehension regarding Milikan's oil drop materials.

CONCLUSION

Based on the results of development study conducted through several stages, the researchers concluded that: this development study has produced a teaching material product in the form of a virtual laboratory-based experiment module for students of the Department of Physics Education at Universitas Muhammadiyah Metro. This study was referring to the ADDIE development model with analysis, design, development, implementation, and evaluation stages. The developed module contains materials concerning Milikan's oil drop. This module is print, containing materials, experimental measures of virtual laboratory, and evaluations in the form of multiple choices.

The acquired research results indicated that the developed virtual laboratory-based experiment module on Milikan's oil drop materials is feasible to be used as a teaching material for educators and students in the learning process based on the total acquisition of mean scores of media and material experts, namely 84.75%, which fell in very feasible category.

The acquired research results indicated that the developed virtual laboratory-based experiment module on Milikan's oil drop materials is very appealing to be used as a teaching material for educators/teachers and students with an overall student response score of 90.51%, which fell in very appealing category.

Based on the results of the conducted development research, the researchers suggest that the virtual laboratory-based experiment module on Milikan's oil drop materials to be used by students of Physics Education at Universitas Muhammadiyah Metro as an independent teaching material; the virtual laboratory-based experiment module on Milikan's oil drop materials as a teaching material can be used by all students with a barcode that has been available on the address of product availability; and the development of virtual laboratory-based experiment module can be developed in

other physics materials perceived as difficult by students.

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