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Development of A Based Multirepresentation Learning Module for Vector Operations at SMA N 42 Jakarta

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Abstrak. Physics is a subject that emphasizes mastery of concepts, moreover in physics material not only theory but there is also a practicum so that students better understand the material. Therefore, virtual practicum media such as the Physics Education Technology (PhET) application is needed with multi representatiomodule teaching materials that can improve mastery of concepts and guide students to use PhET practicum simulations. This study aims to produce modules on vector operation materials that are suitable for use and find out the response of class XI students to the module. This research uses the R&D (Research and Development) method, with the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model. The data collection technique used is an expert validation questionnaire and student response. Based on the validation results of material experts obtained an average of 89% and the validation results of media experts obtained an average of 84%. The response of student questionnaires to the module was obtained on average by 82%. It can be concluded that the validation results from both validators got a very decent category and received a very positive response from the student questionnaire response.

Keywords: Multirepresentation Learning Module, Vector Operations, PhET Simulation, and R&D

I. Introduction

Learning for secondary level students must be developed with appropriate learning strategies [1]. Moreover, in physics learning where the subject is centered on understanding concepts, in reality students are sometimes unable to understand the physics concepts being studied [2]. Students will experience difficulties and will not be able to solve problems in physics correctly if they do not understand the concepts well [3]. Therefore, teachers need to create modern learning tools, namely the availability of learning media as a tool to support motivation for students, especially in physics material, not only theory is only presented but there are also practicums carried out so that students are able to better understand the concepts of the material being taught. given by the teacher [4].

Based on the results of observations related to the implementation of research at SMA Negeri 42 Jakarta, the teacher stated that because there were many practicum modules that should have been available in the school, many had been scattered and lost, making it difficult for teachers to use the practicum modules. So when studying physics which requires students to do practical work, the teacher can only assign students to write down the procedures for doing practical work, tools and materials for practical work, how to analyze

data and practical results which allows students to experience a little difficulty. Apart from that, due to the limited tools available, there is a lot of material that cannot be put into practice directly. Therefore, virtual practical media is needed that is able to visualize physics material, so that students can carry out experiments.

Practical media which is very often used in the current learning process and is an alternative for students to carry out experiments online so that students can continue to develop their creativity is the Physics Education Technology (PhET) application.[5], [6]. Physics Education Technology (PhET) is a website that provides virtual physics, chemistry and mathematics learning which can be freely downloaded for teaching and learning purposes in class or also for individual learning purposes. [7]. Because thanks to current technological advances, students can use virtual practicums through applications (PhET). The PhET simulation is carried out interactively so that students can learn directly. To create efficient and effective physics learning, PhET practicum media cannot be provided directly, teaching materials are needed that can guide students using PhET practicum simulations..

Students studying physics must understand a variety of representations, including graphs, conceptual/verbal descriptions, formulas, and images. A form or arrangement that in a certain way can explain, describe, or show anything is called a representation [8]. Multirepresentation can be interpreted as re-presenting the same concept in different formats, including verbal, pictorial, graphic and mathematical. However, in reality at school students still cannot understand the concept of various representations, many students can only understand one representation, such as students can only focus on one understanding but not another understanding. [9], [10].

The availability of teaching materials is one of the factors that helps the success of the learning process in the classroom. Teaching materials are learning resources that are prepared and used by teachers and students during the learning process [11]. One example of teaching materials can be in the form of modules, modules are learning programs that can be studied by students with minimal assistance from the teacher, including planning the goals to be achieved clearly, providing learning materials, the tools needed, and tools for assessing and measuring the success of participants. students in completing learning [12]. The module developed must be able to make students understand physics concepts well. Therefore, a multi-representation learning module was developed which can improve students' mastery of physics concepts.

By developing multi-representation-based learning modules that contain material in a complete, systematic manner and are also supported by visual explanations for abstract material in a simple way, it can adjust students' level of thinking. [8]. The physics learning module which is presented through multiple representations will contain verbal, mathematical, pictorial and graphic representations. By containing vector operations material in accordance with the material that the teacher is currently teaching in class XI, vector operations material is taught in class XI because SMAN 42 Jakarta has used the independent curriculum.

Based on research from Humnatul Haniyah [8], in his research related to the development of a multi-representation-based module on class XII SMA/MA quantum phenomena material. The results of this research were that the multi-representation-based learning module on quantum phenomena material was declared feasible. The results of the assessment presentation from five material experts were 87.2% in the very appropriate category, three media experts were 85.5% in the very appropriate category, and two language experts were 96.2% in the very appropriate category. The teacher response result was 86%, and the student response result was 71.25%. So it can be concluded that multi-representation based modules are quite practical

II. Method

This research was conducted at SMA Negeri 42 Jakarta, in the even semester of the 2022/2023 academic year. The time required for this research process from start to finish is 8 months April-December 2022. The research design applied is Research and Development (R&D). Research and development using the Analysis, Design, Development, Implementation and Evaluation (ADDIE) method, namely research using a scientific method by analyzing, designing, developing, implementing and evaluating. The module that will be developed for its use is a PhET-based multi-representation learning module on vector operations. Vector operations are class XI physics material which is very closely studied in everyday life. Therefore, a PhET-based multi-representation learning module is used to encourage students to think critically and better understand the material from the module that has been created. The product produced in this research is a PhET-based multi-representation learning module on vector operations material for class XI high school.

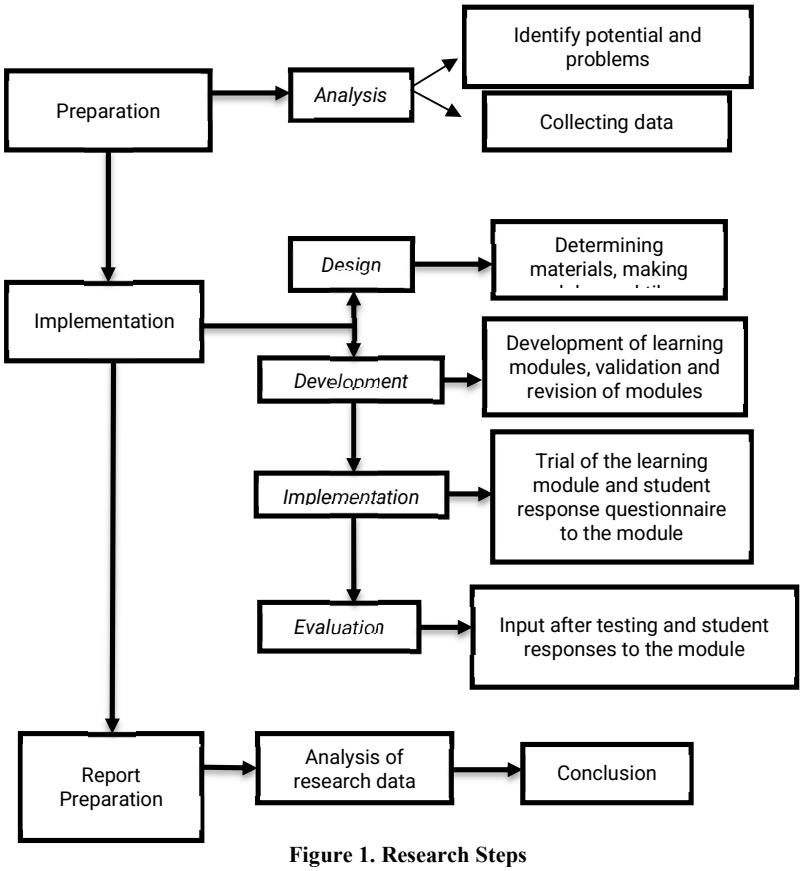

Figure 1. Research Steps

Analysis

Analyze the potential and problems obtained and solve them with the right solution. Researchers at this stage focused on analyzing the learning process and the condition of learning support facilities. Furthermore, to overcome existing problems, researchers developed a PhET-based multi-representation learning module as a teaching material media to solve these problems.

Design

The product design stage is carried out by determining the material and creating a concept design for the PhET-based multi-representation learning module. Making products based on a study of book literature related to the materials to be used in the resulting product. The preparation of this product was carried out using the Canva design application on the cover and contents of the module which was done online.

Development

Product manufacturing is carried out to produce previous designs that have been evaluated by the supervising lecturer. The product produced is in the form of a PhET-based multi-representation learning module as teaching material that can be used during the learning process for class XI students at SMA Negeri 42 Jakarta. After the module has been created, product feasibility/validity testing is carried out by expert validators who are competent in their fields, namely 2 material experts and 2 media experts. At this stage too, the product is revised based on suggestions from the validator. This revision was carried out to obtain the best product design. The instrument that will be used to validate this module is a questionnaire. The results of the questionnaire validation will be analyzed descriptively in consideration of revising the product.

Implementasi

At this stage, the PhET-based multi-representation learning module that has been created and revised based on comments and suggestions from validators will be tested on class XI students at SMAN 42 Jakarta during the learning process activities. After the teaching material product is used, students as media users are then given a response questionnaire. The questionnaire was given to determine student responses to the modules that have been used.

Evaluation

The resulting product is a PhET-based multi-representation learning module in class XI, which has been tested on students. The aim of this stage is to provide feedback to students, so that revisions are prepared according to the evaluation results or needs that cannot be met by the PhET-based multi-representation learning module. The final goal of evaluation is to measure the achievement of development goals. Response analysis was carried out using a Likert scale.

III. Result and Discussion

1. Product Design

The resulting product is a multi-representation learning module based on PhET on vector operations material. Making the module using the Canva application which displays the cover section and the contents of the module. The module design created by the author is as follows:

a. Module Cover

The module cover was designed using the Canva application. In the front design display, the module cover contains the author's study program, faculty and university, the name of the product, namely the practicum module, the material title, namely vector, the level of material presented, namely for SMA/MA class XI, the name of the author, and supporting images presented to illustrate the content. /material taught.

b. Foreword

The foreword is a partial introduction for readers before entering the contents of the module. In the foreword, the author expresses his gratitude to God Almighty because the author was able to complete the module. There is also a general description of the module regarding the benefits of the module, as well as the author's hopes for the usefulness of the module for module users. The author also expects criticism and suggestions from all parties regarding this module.

c. Table Of Contents

The table of contents consists of foreword, table of contents, core competencies, basic competencies, indicators, learning objectives, concept map, vector material, PhET practical steps, student worksheets, sample questions, practice questions, conclusions, answer keys, bibliography, as well as motivational words that the author provides at the end of the module sheet.

d. The Concept Map

The concept map in the module contains a schematic chart of the material that will be studied in the vector module, starting from understanding to depicting vectors.

e. Learning Objectives

In this section, the learning objectives in the module are used to determine the steps that students need to take to achieve the learning objectives that have been set.

f. Learning Activities

In this section there are material contents, objectives of practical experiments, tools and materials, practical steps with PhET simulations, and worksheets intended for students.

g. Exercises

After studying the material and doing the practicum, students will practice doing practice questions to help students understand vector material. From the questions given, it will be seen to what extent students understand vector material.

h. Bibliography

At the end of the module sheet there is a bibliography created to show several references from various books that are appropriate to the material presented.

2. Development Product

The product created is a multi-representation learning module based on PhET as teaching material that can be used during teaching and learning activities for class XI students at SMA Negeri 42 Jakarta. After the module is created, a product feasibility/validity test is carried out by expert validators who are competent in their fields, consisting of 2 material experts and 2 media experts. At this stage too, the product is revised according to suggestions from the validator. This revision was carried out to obtain the best product design.

a. Module Feasibility Based on Expert Validation

A product is declared suitable if it has been validated by competent experts in that field, so that the product can be used in the teaching and learning process. Validation is carried out on the modules that have been produced using 4 validators, namely 2 material expert validators and 2 media expert validators.

b. Subject Matter Expert Validation Results

Material expert validation was carried out by filling out a questionnaire instrument in this research consisting of 4 assessment aspects, 14 indicators and 53 statements. The assessment of the subject matter questionnaire was carried out by 2 validators.

Table 1. Subject Matter Expert Validation Results

No	Assessment Aspects	Validator Validation Value		Average	Max Score	Percentage
		1	2			
1	Content Eligibility	102	86	94	105	90% ("Very worthy")
2	Multi-Representation Based	43	36	39,5	45	88% ("Very worthy")
3	Feasibility of Presentation	74	60	67	75	89% ("Very worthy")
4	Linguistic Feasibility	38	32	35	40	88% ("Very worthy")
Average value						89% ("Very worthy")

The table shows the percentage of feasibility tests based on 4 aspects, the results from material expert validation of content feasibility have a percentage score of 90% with the "very feasible" category, multi-representation based indicators have a score of 88% with the "very feasible" category, the presentation feasibility indicator has a percentage of 89% in the "very appropriate" category, the linguistic appropriateness indicator has a percentage of 88% in the "very appropriate" category. Overall the feasibility of the PhET-based learning module for vector operations material by subject matter expert validators is 89% with the feasibility category "very feasible". This is based on comments from validators, namely that this learning module is good and suitable for use.

c. Media Expert Validation Results

Media expert validation is carried out by filling out an assessment questionnaire instrument consisting of 1 assessment aspect, 3 indicators and 25 statements. The media questionnaire assessment was carried out by 2 validators. Table 2 shows the percentage of assessment results by validators based on the questionnaire assessment aspects

Table 2. Media Expert Validation Results

No	Assessment Aspects	Validator Validation Value		Average	Max Score	Percentage
		1	2			
1	Media Eligibility	112	98	105	125	84% ("Very worthy")
Average value						84% ("Very worthy")

In table 2, based on the results of media expert validation, a feasibility percentage of 84% was obtained in the "very feasible" category. Overall the feasibility of the PhET-based learning module for vector operations material by media expert validators is 84% with the feasibility category "very feasible". This is based on validator comments, namely that basically the module is good and extraordinary.

d. Design Revision

After the validator carried out the validation, the data obtained in the form of criticism and suggestions for improvement by the expert validator were used by the researcher to revise the development of a PhET-based multi-representation learning module for vector operations material in class XI at SMAN 42 Jakarta.

e. Product manufacturing

The development of a PhET-based multi-representation learning module for vector operations material in class XI at SMAN 42 Jakarta was declared valid because it was revised. The next step, the module is created in PDF form and shared in the form of a link from the flipbookpdf.net website with the module link address https://flipbookpdf.net/web/site/0aeea208eadab3397bf4337cd790cae0a9d183382022l2.pdf.html to create modules that can be read like a book, then tested directly on students.

f. Product Implementation

The research was carried out at SMA Negeri 42 Jakarta with 1 meeting in the Physics A specialization class with 32 students and the Physics C specialization class with 26 students. The group divisions in each class are 3 groups consisting of 7 to 9 people per group. The aim of the distributed groups is to work on practical Student Worksheets using PhET simulations which are carried out based on the modules that have been distributed. The aim of this research is to understand the use of multi-representation learning modules using PhET simulations. The instrument in this research was a questionnaire with 20 statement items which were then distributed to students. The researchers collected data with the help of physics teachers and students who at that time were carrying out PKM (Teaching Skills Practices) in that class. The sample in this research was class XI students at SMAN 42 Jakarta. This student response questionnaire will be a consideration for evaluating what is still lacking in the product.

3. Evaluation Results

After distributing the questionnaire instruments to students, we will see how students respond to the modules that have been developed, so researchers can conclude that the modules developed are suitable or not suitable for use. To find out the student's response questionnaire to the resulting module, the researcher first carried out a PhET practicum for vector operations material after that distributed the questionnaire to students. The questionnaire consists of 4 indicators and 20 statements. Analysis of student questionnaire responses to the module was carried out at SMA Negeri 42 Jakarta with a total of 47 students taken in class fill in student worksheets to find out understanding of the material that has been given in the virtual physics education technology (PhET) practical trial through the vector operations module. Calculating data from 47 students obtained a max score of 235 where the value was obtained from the number of students multiplied by the alternative assessment in the questionnaire. Table 3-6 shows the assessment results for each assessment indicator.

Table 3. Assessment Results for Each Interest Indicator

Statement	Total score	Percentage	Category
1. The physical appearance of the practical module (combination of colors, images and module cover) is interesting to study.	202	86	Very Positive
2. This practical module makes me more enthusiastic about studying physics.	196	83	Very Positive
3. Using this practical module can make learning physics less boring.	194	83	Very Positive
4. The presence of motivational words in this vector module influences my attitude and learning.	189	80	Positive
Average percentage		83	Very Positive

Table 4. Assessment Results for Each Content Indicator

Statement	Total score	Percentage	Category
1. The material presented in this module is related to everyday life.	184	78	Positive
2. The instructions in this module are easy to understand.	196	83	Very Positive
3. The material/illustrations presented in this practical module are easy for me to understand.	200	85	Very Positive
4. All tools and materials for experimental activities are clearly presented in the practical module.	199	85	Very Positive
5. The practical answer sheet makes it easier for me to write practical results.	191	81	Very Positive
6. This module contains practice questions that can test some of my understanding of Vector material.	193	82	Very Positive
7. Delivery of material in the practicum module is related to everyday life.	179	76	Positive
8. The practicum module encouraged me to be physically and mentally creative in learning.	186	79	Positive
9. The presentation of material in the module encourages me to discover concepts to study independently.	187	80	Positive

Average percentage	81	Very Positive

Table 5. Assessment Results for Each Language Indicator

Statement	Total score	Percentage	Category
1. The language used in the module is simple and easy to understand.	190	81	Very Positive
2. The language used is in accordance with EYD.	191	81	Very Positive
3. The sentences and paragraphs used in this module are clear and easy to understand.	192	82	Very Positive
Average percentage		81	Very Positive

Table 6. Assessment Results for Each Multi-Representational Learning Component Indicator

Statement	Total score	Percentage	Category
1. The presentation of material, images, graphs and formulas/equations in this module helped me understand the vector operations material.	188	85	Very Positive
2. The display of images, formulas/equations, material and graphics contained in the module are visualized in an interesting way so that it makes me understand more about the concept of vector operations material.	186	85	Very Positive
3. This module contains graphs, material, formulas/equations and images in line with the description in the module.	185	84	Very Positive
4. The material, formulas/equations, graphs and images presented in the module provide explanations that are easy for me to understand.	182	83	Very Positive
Average percentage		84	Very Positive

Student responses to the PhET-based multi-representation learning module are said to be very positive if the overall percentage results of the assessment indicators reach an average percentage value of 81%-100%. The results of the student response assessment were given to 47 students of class XI Physics A and C at SMAN 42 Jakarta. The percentage of student responses was made to four indicators, namely the interest indicator scored 83% in the "very positive" category, the content indicator scored 81% in the "very positive" category, the language indicator scored 81% in the "very positive" category and the learning component indicator multirepresentation scored 82% in the "very positive" category.

Based on student responses to the PhET-based multi-representation learning module for vector operations material. The indicator of interest in the module received a "very positive" response with a percentage of 83%. The results obtained are in accordance with the contents of the questionnaire which contains the physical appearance of the module (combination of colors, images and module cover) and motivational words in the module in the form of cartoon images. This is in line with the validation scores obtained by media experts who received an average result of 84%, proving that the response from students to the module display and the media expert validation scores obtained an average score of almost the same or equivalent.

The module content indicator received a "very positive" response with a percentage of 81%. The results obtained are in accordance with the contents of the questionnaire which contains material related to the module, instructions in the module, illustrations of the material presented, PhET practicum tools and materials in the module, student worksheets related to PhET practicum in the module, practice questions, and presentation material in the module.

The learning module language indicator received a "very positive" response, namely with a percentage of 81%. The results obtained are in accordance with the contents of the questionnaire which contains the language used in the module is simple, easy to understand and the language used is in accordance with EYD.

The multi-representation learning component indicator in vector operations material received a "very positive" response, namely with a percentage of 82%. The results obtained are in accordance with the contents of the questionnaire which contains sentences to encourage students to want to learn through observing/digging up information related to learning material, giving students the opportunity to be more active in asking questions, carrying out virtual practical experiment activities by following each stage and providing opportunities to communicate the main material. discussion of vector operations and through practicum.

The results of the analysis of the overall average percentage of student responses to each indicator from the data above obtained a percentage of 82%. Based on the percentage score obtained, it was concluded that the development of the PhET-based multi-representation learning module received a "very positive" response from 47 students, so the module is suitable for use for physics teaching and learning activities in schools, especially on the subject matter of vector operations.

IV. Conclusion

1. The module was declared suitable for use based on the validation results of subject matter experts, media experts, and the results of student response questionnaires. The validation results from material experts obtained an average score of 89% in the "very feasible" category. The validation results from media experts obtained an average score of 84% in the category "very suitable" for use.
2. The results of responses by students obtained a percentage of 82%. Based on the percentage scores obtained, it was concluded that the development of the PhET-based multi-representation learning module received a "very positive" response from 47 students.
3. Researchers conducted interviews with physics teachers regarding module development and received a positive response that this learning module could make it easier and help teachers in carrying out learning.

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