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Development of Physics REACT Module Assisted With PhET Simulations on Harmonic Vibration Materials

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ABSTRACT
Technology in the milenial era is developing so rapidly and has an impact on the world of education. The world of education is required to harmonize learning methods and media used with technological development. The lack of direct practicum activities in several schools has resulted in students' understanding of the material presented not as expected. Physics REACT module assisted by PhET simulations on harmonic vibration material can be a solution for delivering harmonious vibration material with practically practicum activities. This study aims to determine the validity of the modules that have been developed and the effectiveness of the modules. This research includes development research using the Nieveen development design. This module is equipped with explanations in accordance with the REACT approach and practicum activities using PhET. The subjects of this study were students of class XI IPA 3 at SMAN Bandarkedungmulyo Jombang. The results of expert validation were 94.4% with the very feasible / valid category, while the results of user validation were 96.09% with the very feasible / valid category. Student physics learning outcomes have increased, this can be seen from the acquisition of N-Gain in the limited test of 0.6 in the medium category and in the field test of 0.7 in the high category. Not only N-Gain method, you can also use the t-test. It can be concluded that the REACT physics module assisted by PhET simulations on harmonic vibration material is very feasible and effective to be used in the learning process.

INTRODUCTION

In the milenial era that is currently happening, technological developments continue to increase rapidly. This can have an impact on the world of education, where education also has an important role in the progress of the country so that as technological developments continue to increase, it must be accompanied by the world of education which must also develop methods or means and

infrastructure used by educators so that they are not out of date. The government demands that the learning process be better in accordance with the times.

Learning is an educator's effort to help students in their learning activities using approaches, strategies, and methods towards a predetermined direction or planned learning objectives [1]. [2] Meanwhile, according to Druxes, physics is a science that explains and describes natural laws and events in the universe with a picture according to the human mind. Learning physics requires a supporting book or a type of supporting teaching material to help improve the understanding of the participants 'concepts, which makes students more active in the learning process and along with it improves students' physics learning outcomes. Student creativity can be created by simulating or practicing the material to be presented, where the simulation used is the PhET simulation. PhET simulation is not a strange thing anymore because it can be accessed easily, even though there are still many schools that are not yet capable of implementing PhET, even direct practicum is still very rare. Therefore, it requires learning innovations that utilize technology such as this PhET simulation to improve students' understanding of concepts through virtual visualization through PhET simulations. When a conceptual understanding is formed, students are able to apply this understanding not only through visualization to the PhET simulation but are able to apply it in real life.

PhET simulation is a form of virtual simulation that has several advantages compared to real-world experiments using teaching aids. The advantage of PhET simulation is the shorter time it takes to do the experiment. [3] In his research, Finkelstein stated that solving the circuit using the PhET simulation takes an average of about 14 minutes when compared to using the props which takes about 17.7 minutes. Apart from this, the use of PhET simulations can also increase student interest in learning and student learning outcomes. [4] Marlinda stated that learning assisted by PhET simulation could increase student learning activities, from 88.61% to 96.11%. [5] Ismaun stated that learning using PhET simulations can improve students' understanding of the concept, which can be seen from the significant level obtained, namely 0.025 <0.05, which can be explained if there is an effect of using PhET simulations on understanding the concept of molecular models.

The success of learning in schools, apart from being influenced by the use of the right media, also requires a module that is in accordance with the material being taught. Modules are considered as pedagogical tools that provide solutions to improve student learning outcomes and student conceptual understanding. [6] The Ministry of National Education stated that the developed module has the main objective of increasing the effectiveness and efficiency of the learning process, not only that students can learn thoroughly and be more active in the learning process. [7] The use of the REACT physics module in the physics learning process is able to increase multiple intelligence and creativity of students even though it is classified as low with a gain of 0.23. [8] The use of the REACT physics module can improve students' conceptual understanding by obtaining an N-gain of 0.71, which is included in the high effectiveness category. Meanwhile, according to [9] the use of physics modules can improve the cognitive learning outcomes of students by obtaining an N-gain of 0.74 for the effectiveness of the module and the percentage of student activity is 96.2%.

The learning model is a planning framework before learning in order to achieve the desired learning objectives. In this case, the learning model supports the development of this module, namely the REACT learning model which includes Relating, Experience, Applying, Cooperating, and Transfering. REACT is a contextual learning model in which there are five stages in the learning process, namely Relating, Experiencing, Applying, Cooperating, and Transfering which aims to invite students to find concepts, collaborate, and apply the current understanding of the material (concepts) in everyday life. [10] The application of the REACT learning model can improve student learning outcomes. [11] REACT learning model is contextual learning. The REACT model is a contextual learning model that was first applied in the United States, where contextual learning is learning that is related to the material being taught and its application in everyday life [12]. Not only that, this REACT learning model involves students directly in connecting the prevailing concepts with the

phenomena or events around them through experiments to experience them in groups to form an understanding of the concept [13].

The PhET simulation-assisted REACT module is a module characterized by the syntax of REACT learning assisted by the PhET simulation in the experiment. The relationship between the PhET simulation and the REACT approach, namely the PhET simulation, is able to smooth the syntactic steps of the REACT approach, which starts from connecting concepts with everyday life to transferring learning outcomes using PhET simulations with the REACT approach to others. This REACT module makes students able to learn independently without depending on the teacher (self-instructional) and the Phet simulation provided is able to attract students' interest in learning, especially on harmonious vibration material. The selection of the REACT physics module with the help of PhET simulation is one of the various approaches used in the physics learning process so that students understand better the concepts that apply in the material and their application through practically practically using PhET simulations. Harmonic vibration material is chosen because harmonic vibration is a material that simulates a waveform resulting from a movement or vibration that occurs in an object. Not only that, the application of concepts that apply in the material of harmonious vibrations in everyday life has even been done by students, for example the concept of a mathematical pendulum on a swing.

In accordance with the description above, the researcher conducted a study aimed at determining the validity and effectiveness of the physics REACT module assisted by PhET simulations. This is done in order to create physics learning innovation so that students do not feel that physics is a difficult subject. Not only that, but students are also able to apply the concepts that have been conveyed into everyday life.

METHOD

The development of a physics REACT module assisted by PhET simulations on harmonic vibration material uses the Research and Development (R&D) research method with the Nieveen development model. The Nieveen development model has 3 stages in its implementation, namely Preliminary Research (preliminary study), Prototyping Stage (planning stage), and Assessment Stage (assessment stage) as shown in Figure 1. The object of research is the students of class XI IPA 3 at SMAN Bandarkedungmulyo Jombang.

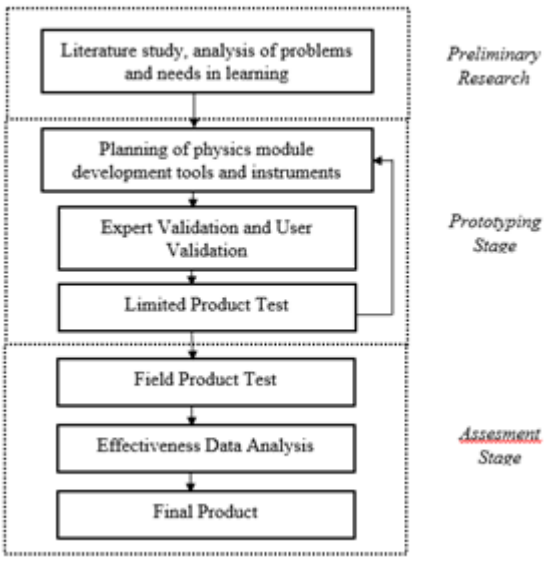


Fig 1. *The Nieveen Development Model*

The data collection technique is in the form of expert validation sheets given to two expert validators from Physics Education lecturers, Faculty of Teacher Training and Education, Jember University, user validation sheets given to physics subject teachers in class XI IPA at SMAN Bandarkbuildingmulyo Jombang, pretest and posttest results. Pretest and posttest questions were given to students in class XI IPA 3 with 23 students for field testing and 8 students for limited tests taken from three other science classes randomly. Pretest and posttest questions are made with the same score and difficulty level of the questions, this is because it is to determine the effectiveness of the modules that have been developed on improving student learning outcomes.

The validation stage is the stage to test the validity or feasibility of the modules that have been developed before they are tested at the target school. The assessment or validation of this module consists of 18 statements with a weighted score from 1-4. Table 1 shows the qualifications from the calculation results of expert validation and user validation [14].

Table 1. Categories of assessment of learning device validation

Qualitative Criteria	Percentage Range
$82\% \leq P \leq 100\%$	Very Worth It
$63\% \leq P < 82\%$	Well Worth It
$44\% \leq P < 63\%$	Not Worth It
$25\% \leq P < 44\%$	Not Feasible

The results of expert validation and user validation can be calculated by the following equation [15]:

$$P = \frac{f}{N} x\ 100\% \quad (1)$$

The next stage is testing by giving a pretest and posttest into two stages of testing. The first trial was the limited cioba test where the research subjects were 8 students from three XI IPA classes who were randomly selected. While the second trial is the field test where in the field test the research subjects were 23 students from class XI IPA 3. The data processing of the pretest and posttest results used the N-Gain test with the categories in table 2 below [16]:

$$g = \left(\frac{S_f - S_i}{S_{max} - S_i}\right) \quad (2)$$

Table 2. Criteria for the gain score

Normalized gain score	Categories
$\langle g \rangle \geq 0{,}7$	High
$0{,}3 \leq \langle g \rangle < 0{,}7$	Moderate
$\langle g \rangle < 0{,}3$	Low

Another method that is stronger in proving the effectiveness of the module based on learning outcomes is using the t-test in SPSS, only in this study the data cannot be measured using the t-test because the requirements for the t-test are normally distributed data. The data in this study were not normally distributed because the data obtained were in accordance with the facts in the field regarding student learning outcomes.

RESULTS AND DISCUSSIONS

Result

1. Description of Development Results

The product developed in this research is the REACT physics module assisted by PhET simulations on harmonic vibration material. This research is a development research that uses the development design of Nieveen (2006), where there are three stages, namely, 1) preliminary research (preliminary study);

2) prototyping stage (design stage); and 3) assessment stage.

a. Preliminary Research

The first step is analyzing the problems obtained based on the results of an interview with one of the physics teachers at SMAN Bandarkbuildingmulyo Jombang. In accordance with the results of the interview, it can be concluded that online learning with limited learning media with explanations makes students unable to understand the material well plus there is no virtual practicum that students can use in understanding the concepts of physics in each material.

The second step is a literature study on the problems that occur in students. [17] The problem that occurs in the learning process is the inactivity of students so that learning is only centered on the teacher even though the teacher has delivered learning using supporting learning media but students only listen without asking. [18] The problem that occurs to students is the lack of relevance of the student worksheets provided where the worksheets do not train students' abilities in honing their abilities in understanding the material that has been presented. [19] The problem with students is the lack of experimental activities due to the limitations of practicum tools, so that students are confused in connecting the concept with real life.

The third step is needs analysis to determine the curriculum used in schools. The basis for developing this module is a review of the 2013 revised curriculum which includes core competencies (KI), basic competencies (KD), and learning objectives. Basic materials and competencies (KD) can be seen in table 3 below:

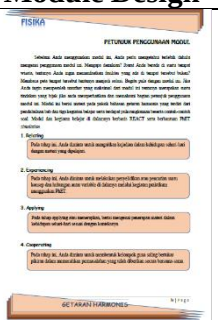
Table 3. Material and Basic Competencies (KD) of Harmonious Vibration

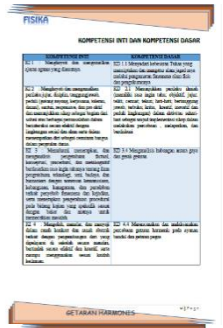
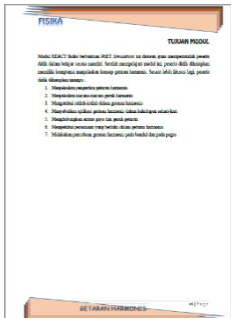
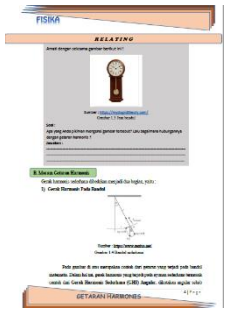
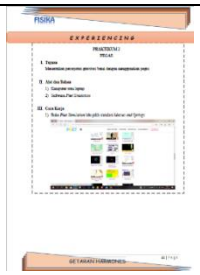
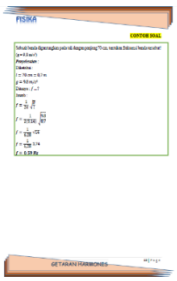
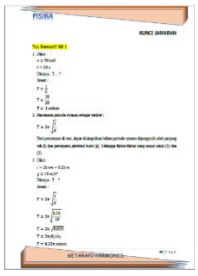
Material	Basic competencies
Harmonious Vibration	3.4 Analyzing the relationship between vibration force and motion 4.4 Planning and carrying out harmonic vibration experiments on pendulum swings and vibration springs

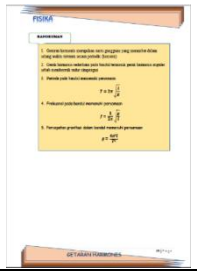
b. Prototyping Stage

At the design stage of this product, the product to be developed is a physics REACT module assisted by PhET simulations on harmonic vibration material. This module was developed by fulfilling the stages in the REACT approach, so that each learning activity in the module is structured in the REACT approach as follows: 1) relating; 2) experiencing; 3) applying; 4) cooperating; and 5) transferring. The module parts can be seen in table 4 below:

Tabel 4. Module Layout

Module section	Module Design	Module section	Module Design
Cover		Instructions for Usingthe Module	

Core Competencies and Basic Competencies		Module Objectives	
Concept maps		Provision of images related to the concept*(relating)*	
Providing virtual practicum using PhET*simulations (experiencing)*		Provide space for students to exchange ideas with their friends in connecting practicumresults with applicable concepts *(cooperating)*	
Applying the conceptof harmonious vibrations in everydaylife *(applying)*		Problems example	
Provision of formative tests as a measure of the abilityof students to understand the material in each learning activity *(transferring)*		Answer key	

Summary			

At the design stage, the developed module needs to be validated to measure the validity or feasibility of the module developed before it is implemented in schools. The validation process is divided into two, namely expert validation carried out by two expert validators and user validation carried out by class XI IPA subject teachers. The results of expert validation are described in table 5 below:

Table 5. Expert Validation Results

No	Aspects Considered	Average Aspect (%)	Validity (%)	Rate Validity
1	Construct	98.44%	94.4%	Very Worth it
2	Contents	87.5%		
3	Needs	95.83%		
4	Language	95.83%		

The results of expert validation based on table 5 can be explained that: the average construct aspect is 98.44%, the average content aspect is 87.5%, the average needs aspect is 95.83%, and the language aspect average is 95.83%. In accordance with this, the overall validity results of the expert validation process were 94.4% with very proper qualifications or it can be said that the REACT module assisted by PhET simulations on harmonic vibration material is declared very valid.

The next stage is user validation, user validation is carried out by a physics subject teacher in class XI IPA at SMAN Bandarkedungmulyo Jombang. The results of user validation are described in table 6 below:

Table 6. User Validation Results

No	Aspects Considered	Average Aspect (%)	Validity (%)	Rate Validity
1	Construct	96.875%	96.09%	Very Worth it
2	Contents	100%		
3	Needs	91.67%		
4	Language	95.83%		

The results of user validation based on table 6 can be explained that: the average construct aspect is 96.875%, the average content aspect is 100%, the average requirement aspect is 91.67%, and the language aspect average is 95.83%. In accordance with this, the overall validity result of the expert validation process is 96.09% with very proper qualifications or it can be said that the REACT module assisted by PhET simulations on harmonic vibration material is declared very valid.

After the validation stage is carried out to measure the validity or feasibility of the module being developed, the next stage is the trial phase. The coiba test stage is divided into two, namely, limited trials and field trials. Limited trials were carried out randomly from class XI MIPA 1, XI MIPA 2, and XI MIPA 4 by taking a sample of 8 students. Limited trials were conducted three times online via google meet due to the Covid-19 pandemic. This limited trial was carried out by providing a pretest and posttest to measure the effectiveness of the developed module. The details of the comparison of students' pretest and posttest scores can be seen in table 7 below:

Tabel 7. Limited N-Gain Test Results

Components	*Pretest*	*Posttest*	N-Gain	Categories
The highest score	50	85	0.607652174	Moderate
Lowest score	10	50		
Average	28.125	71.8		

According to table 7, it was found that the average pretest score was 28,125 and the average posttest score was 71.8. So that the N-gain is obtained of 0.6 in the medium category, meaning that the level of effectiveness of the module developed based on the increase in student learning outcomes can be classified as effective.

c. Assesment Stage

The product appraisal stage is an assessment of the REACT physics module assisted by PhET simulations on harmonic vibration material. This assessment stage is carried out on large-scale students (field testing). Field tests were carried out on students in class XI MIPA 3 with a sample of 23 students. Details of the results of the pretest and posttest in the field test class are as in table 8 below:

Tabel 8. Field Test N-Gain Results

Components	*Pretest*	*Posttest*	N-Gain	Categories
The highest score	60	90	0.728896377	High
Lowest score	20	70		
Average	40.65	83.91		

According to table 8, it is found that the average pretest score is 40.65 and the average posttest score is 83.91. So that the N-gain is obtained of 0.72 with the high category. This shows that there is an increase in learning outcomes after using the REACT physics module assisted by PhET simulations on harmonic vibration material. So it can be concluded that the module is very effective for use in learning material harmonious vibrations.

Discussions

This research was conducted to develop a physics REACT module assisted by PhET simulations on harmonious vibration material in order to provide innovative physics learning and support the online learning process independently by class XI IPA high school students. This study aims to determine the validity and effectiveness of the modules that have been developed when used in learning in senior high schools (SMA).

1. Validation of Physics REACT Module assisted by PhET Simulations

Validation is a stage to assess the validity of the product developed before it is tested on students. The product developed in this research is the REACT physics module assisted by PhET simulations on harmonic vibration material. This validation process is carried out by two expert validators and one user validator. The expert validation process obtained the validity of 94.4%, the total validity value was included in the very feasible category which means it is very feasible to be applied to high school. Whereas in the validation process the user obtained a validity of 96.06%, the multiple validity values were included in the very feasible category which means that it is very feasible to be applied to high school. construct, content, needs, and language.

2. Effectiveness of Physics REACT Module assisted by PhET Simulations on Harmonious Vibration Material

Effectiveness is an effort made in accordance with the needs in achieving predetermined goals or

targets, where this is in accordance with the plan both in data use or physical activity in order to get maximum results. In accordance with the description above, it is concluded that the effectiveness of teaching materials is the ability of a teaching material (in the form of modules) in its implementation into the learning process in order to achieve learning objectives. Measuring the effectiveness of the teaching materials to be used is indeed very important, this is done in order to achieve the desired learning objectives and students are able to apply the concepts that have been given to everyday life.

The effectiveness of the physics REACT module assisted by PhET simulations on harmonic vibration material can be known based on the results of the students' pretest and posttest. Trials to determine the effectiveness of the module were carried out in two ways, namely limited trials and field trials. In the limited trial, the subjects used were 8 students from class XI MIPA who were randomly selected by the physics teacher at SMAN Bandarkedungmulyo Jombang. Limited trials were carried out for three meetings where for the first meeting before learning using modules, students were given a pre-test or pretest to measure students' initial understanding of the harmonious vibration material. The pretest questions consist of five essay questions with different levels of difficulty and at different times in the process. Furthermore, students carry out learning using the REACT physics module assisted by PhET simulations and work on practicum activities in groups. At the third meeting, namely the last meeting, students did a posttest. The posttest questions have the same indicators as the pretest questions and the processing time is the same as the pretest questions. Based on the results of a limited trial, an n-gain of 0.6 was obtained. According to the N-gain score criteria, it can be concluded that the effectiveness of the physics REACT module assisted by PhET simulations on harmonic vibration material belongs to the moderate category which means that it is effective to be applied in the learning process. This is indicated by a change in the physics learning outcomes of students according to the pretest and posttest values.

The second trial was the field test, where the field test was carried out with 23 students from class XI MIPA 3 at SMAN Bandarkedungmulyo Jombang. Class selection was carried out by a physics subject teacher at SMAN Bandarkedungmulyo Jombang. The field test is carried out the same as the limited test, the difference is only in the number of samples that are more. Based on the results of field tests, an N-gain of 0.7 was obtained. According to the N-gain score criteria, it can be concluded that the effectiveness of the physics REACT module assisted by PhET simulations on harmonic vibration material belongs to the high category which means that it is very effective to be applied in the learning process. This is indicated by a significant change in the physics learning outcomes of students according to the pretest and posttest scores.

CONCLUSION AND SUGGESTION

Conclusions

In accordance with the research that has been done, the physics REACT module assisted by PhET simulations on harmonic vibration material can be concluded as follows:

Physics REACT module assisted by PhET simulations on harmonic vibration material is declared valid or very suitable for use by expert validators and user validators with a validity percentage of 94.4% for expert validation and 96.09% for user validation, so that it can be implemented in a development trial site. Physics REACT module assisted by PhET simulations is stated to be effective enough to improve students' physics learning outcomes by obtaining N-gain in a limited test of 0.6 which is included in the moderate category, while it is declared very effective for improving learning outcomes with the acquisition of N-gain in the test a field of 0.7 which is included in the high category.

Suggestions

For further research, the module can be used in other schools with the same material, only in proving the effectiveness of the module, another method is the T-Test so that stronger results are obtained than the N-Gain method.

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