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Development Of Phet-Based Practice Module Electrical Energy Material For Grade V Students Elementary School

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Abstract: The independent curriculum is designed so that students can achieve the abilities according to those stated in the learning outcomes. In realizing these goals, it is necessary to support the use of creative and innovative learning resources. In reality, there are still many teachers who have not used maximum learning resources, causing student learning outcomes, especially in the science subject, to be less than optimal. So it is necessary to use a PhET-based practice module. The objectives of this study are (1) to describe the analysis of the needs of teaching materials for the electrical material practice module for grade V elementary schools in Jekulo District, Kudus, (2) to describe the design or product of the PhET-based practice module for electrical material for grade V elementary schools, (3) to describe the feasibility or validity of the PhET-based practice module for electrical material for grade V elementary schools that was developed, (4) to explain the effectiveness of the PhET-based practice module for electrical material for grade V elementary schools that was developed. This study uses a Research and Development (R&D) design. The qualitative data analysis of this study used the flow analysis model technique which consisted of data reduction, data presentation and drawing conclusions/verification. Quantitative data used validation tests, normality tests, homogeneity tests, NGain tests and comparison tests. The results of this study indicate that the development of a PhET-based practice module to improve elementary school students' learning outcomes in Jekulo District, in terms of validity, is included in the very valid classification. The results of the questionnaire analysis of teacher and student responses in implementing the PhET-based science practice module obtained an average score of 90% of teachers giving a positive response and 89% of students giving a positive response. The results of the gain score of student learning outcomes, in the experimental class got an average score of 0.45 in the medium category, while the control class got an average of 0.12 in the low category. Testing through the Independent sample t Test obtained a value of tcount = 14.335> ttable = 1.99656 and a sign value. (2-tailed) of 0.000 <0.05, so it can be concluded that there is a difference in the average learning outcome data from the two groups, where the average learning outcome of the experimental group using the PhET-based science practice module is higher than the average control group.

Keywords: Practice Module, PhET, Electrical Energy.

1. Introduction

Permendikbudristek No. 16 of 2022 concerning Process Standards explains that the implementation of learning is carried out in an interactive, inspiring, fun, challenging learning atmosphere, motivating students to actively participate, and providing sufficient space for initiative, creativity, independence according to talents, interests, and physical and psychological development of students. In addition, the implementation of learning is carried out by educators by providing role models, mentoring, and facilitation. As an effort by teachers as facilitators, student learning activities are more directed towards a process approach, namely students find their own answers with a series of activities that support the process of finding answers. In bridging the process approach to finding their own answers, it must be supported by the existence of student learning instruments.

The curriculum is a set of plans and arrangements regarding the objectives, content, and learning materials as well as the methods used as guidelines for organizing learning activities to achieve certain educational goals as stipulated in the General Provisions of Law No. 20 of 2003. Curriculum development is carried out with reference to national education standards as mandated in Article 35 paragraph (2) and Article 36 paragraph (1) of Law No. 20 of 2003. The curriculum at all levels and types of education is developed with the principle of diversification in accordance with educational units, regional potential, and students as mandated in Article 36 paragraph (2) of Law No. 20 of 2003.

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The basic framework and structure of the curriculum for primary and secondary education are determined by the Government and developed according to its relevance by each educational group or unit and school/madrasah committee under the coordination and supervision of the district/city education office or religious affairs office for primary education and the province for secondary education as mandated in Article 38 of Law No. 20 of 2003.

Based on observations and interviews with class V teachers on September 5, 2023, the implementation of learning in class V of SD 1 Tanjungrejo has not been able to take place optimally. The learning outcomes of the SD 1 Tanjungrejo science lessons have not been satisfactory and can still be improved. Teachers only deliver material from teacher textbooks and student books. Lack of teaching materials used by teachers, especially for science material which should require a lot of practical activities and use a variety of teaching materials so that students can more easily understand the science material. From the results of observations and interviews, researchers found several obstacles that occurred in the class, including: (1) students find it difficult to understand the electrical energy material, (2) student learning outcomes are low in the electrical energy material, (3) students find it difficult to demonstrate how electricity is produced and distributed, (4) students do not have interesting media to demonstrate how electricity is produced and distributed.

Explains the purpose of writing a module, namely: (1) To clarify and simplify the presentation of messages so that they are not too verbal, (2) Overcoming limitations of time, space, and sensory abilities, both for students and teachers/instructors, and (3) Using them appropriately and in a variety of ways, such as increasing students' motivation and enthusiasm for learning, developing their ability to interact directly with the environment and other learning resources, allowing students to learn independently according to their abilities and interests, and allowing students to measure or evaluate their own learning. As an effort to improve the quality of learning, one of which can be taken by utilizing technology-assisted learning media. One of the technology media that can be used in learning science in elementary schools is the PhET (Physich Education Technology) simulation. PhET is a science simulation created by the University of Colorado in the form of a simulation of learning physics, biology, and chemistry for the benefit of teaching in schools or independent learning. PhET simulations emphasize the relationship between real- life phenomena and the underlying science, support interactive and constructivist approaches, provide feedback, and provide a creative workplace. The PhET Team explains that PhET is a site that provides simulations of learning physics, biology, chemistry, and mathematics, which are provided free of charge by the University of Colorado for the benefit of classroom learning or can be used for individual learning purposes. The advantages of this simulation are: (1) it can be used as a learning approach that requires involvement and interaction with students, (2) it educates students to have a constructivist mindset, where students can combine their prior knowledge with virtual findings from the simulation being run, (3) it makes learning more interesting because students can learn and play at the same time in the simulation, and (4) it visualizes science concepts in the form of real models.

In previous research by [2] the research method used was the ADDIE Research and Development model, namely analysis, design, development, implementation and evaluation. The subjects of this study were 15 fifth grade students at SD Negeri 1 Suru, Grobogan Regency, odd semester of the 2022-2023 academic year. The data collection techniques used were interviews, tests, observations, questionnaires for assessing validation, practicality, and effectiveness of the media. Based on the results of the study, it can be concluded that the PheT-assisted e-module media meets the criteria of being valid, practical and effective to be applied as a learning medium in improving students' understanding related to fractional arithmetic operations.

From the background above, it is necessary to develop a practice module that can facilitate student activities in science learning using PhET simulation media. This practice module can guide students in conducting experimental activities. The practice module can make students understand the material more easily and independently so that the lesson becomes more interesting, enjoyable, and feels easier to understand. Based on the description above, the researcher considers it necessary to conduct a study entitled "Development of a PhET-based practice module on electricity material for fifth grade elementary school students".

1.1 Conceptual framework

One of the learning methods commonly implemented by teachers to facilitate the explanation of learning materials is through simulation activities. Simulations can also be used to replace real-life practical materials. They provide hands-on experience.

Concrete learning through the process of creating an imitation of an experience that approximates the actual situation and takes place in a safe environment is the goal of simulation (Rusman:2013). According to Sridadi (2009), a simulation is a computer software program that functions to imitate the behavior of a specific real system. Therefore, simulations can be used in the learning process to help students understand a learning concept.

The simulation emphasizes the connection between real phenomena in everyday life and computer simulations, which are then presented in a conceptual model that can be observed and easily understood by both teachers and students.

According to Fitri Y (2016), the benefits of this simulation or experiment are as follows: (a) It can be used as a learning approach that requires student involvement and interaction, (b) Provide dynamic feedback because it's impossible to predict student responses, (c) Students' constructivist thinking patterns will be honed by training them to combine their prior knowledge with that gained through the learning process, (d) By treating learning like a game, students become more engaged and enthusiastic during the lesson, (e) Facilitate students' understanding by visualizing abstract science concepts in the form of models, such as electrons, protons, molecules, energy, electricity, and so on.

1.2 Research objectives

This research aims to obtain an in-depth overview of, among other things: (1) Describe the needs analysis for teaching materials for electrical practical modules for fifth-grade elementary schools in Jekulo District, Kudus, (2) Describe the design or product of a PhET- based electrical practical module for fifth-grade elementary schools, (3) Describe the feasibility and validity of the PhET-based electrical practical module for fifth-grade elementary schools that was developed, (4) Explain the effectiveness of the PhET-based electrical practical module for fifth-grade elementary schools..

2. Research Methods

2.1 Research Design

This study employs the Research and Development (R&D) method, which aims to produce and test the effectiveness of specific products. The development process follows the Borg and Gall model as adapted by Sugiyono, encompassing ten systematic stages: potential and problems, data collection, product design, design validation, product revision, initial product testing, further product revision, usage trials, final product revision, and mass production. For the testing phase, the study utilized a Pretest-Posttest Control Group Design. This design allows for a rigorous comparison between an experimental group, which utilized the Smart Apps Creator (SAC)-based solar system e-module, and a control group that followed conventional learning methods, ensuring that any significant improvement in learning outcomes can be attributed to the intervention.

2.2 Participants

The participants of this research consisted of students and teachers from three elementary schools in the Gugus Melati, Kecamatan Welahan, Kabupaten Jepara. For the limited trial and initial effectiveness testing, the sample included 16 sixth-grade students from SDN 2 Brantaksekarjati as the experimental class and 15 sixth-grade students from SDN 1 Brantaksekarjati as the control class. To ensure the robustness of the findings, an extensive trial was conducted with a larger sample size of 66 students, comprising learners from SDN 2 Brantaksekarjati, SDN 1 Brantaksekarjati, and SDN 2 Kalipucangwetan. Additionally, expert validators including university lecturers specializing in teaching materials, content, and linguistics, as well as practitioners from the school supervisor level, participated in the feasibility assessment of the e-module.

2.3 Research Instruments

Data collection was facilitated through several quantitative and qualitative instruments. Feasibility was measured using validation sheets with Likert scales for media experts, material experts, and linguists. User perception and practicality were captured through student and teacher response questionnaires designed to gauge interest and ease of use. To measure the effectiveness of the e-module on learning outcomes, the study utilized standardized pretest and posttest instruments. These tests were developed based on the cognitive requirements of the Grade VI Science curriculum, focusing on solar system materials. The validity and reliability of these test items were verified prior to administration to ensure they accurately reflected the learning objectives.

2.4 Research Procedures

The research procedure began with a needs analysis involving interviews and observations to identify gaps in existing teaching materials. Following this, the e-module was designed using Smart Apps Creator (SAC) in conjunction with supporting tools like Canva, Heyzine Flipbooks, and Wordwall. The initial design underwent a validation process by experts, followed by revisions based on their feedback. The procedure then moved into the field-testing phase, starting

with a limited trial in the experimental and control classes to obtain initial effectiveness data. After analyzing these results and making necessary refinements, an extensive trial was performed across three schools to verify the product's scalability and consistent effectiveness. The final stage involved mass production and distribution of the APK-based e-module to the wider teacher forum in Welahan District.

2.5 Data Analysis

The data analysis was conducted using a combination of descriptive and inferential statistics with the assistance of SPSS software. Quantitative data from expert validation and user response questionnaires were analyzed using percentage techniques to determine the feasibility level. For the effectiveness analysis, the data first underwent prerequisite testing, including the Kolmogorov-Smirnov test for normality and Levene's test for homogeneity. The improvement in student learning outcomes was quantified using the Normalized Gain (N-Gain) formula to determine the magnitude of the increase between the pretest and posttest. The results of the N-Gain calculation were then classified according to the criteria established by Hake, as shown in Table 1.

Table 1 - Normalized Gain Average Values and Their Classification

Rata-rata Gain Ternormalisasi	Klasifikasi	Tingkat Efektifitas
$\langle g \rangle \geq 0{,}70$	High	Effective
$0{,}30 \leq \langle g \rangle < 0{,}70$	Medium	Quite effective
$\langle g \rangle < 0{,}30$	Low	Less Effective

Finally, an Independent Sample T-test was conducted at a significance level of 0,05 to determine if there was a statistically significant difference in the average learning outcomes between the experimental class and the control class, thereby confirming the effectiveness of the developed e-module.

3. Results

A normality test was conducted to determine the normality of the data. The goal was to verify whether the two sample data came from normally distributed populations. The normality test was conducted using the Komogorov-Smirnov test with SPSS.

Table 2 - Results of the Normality Test for the Experimental and Control Classes

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Kelas	Statistic	df	Sig.	Statistic	df	Sig.
Student Learning Outcomes	Pretest Experiment	.118	16	.200*	.975	16	.916
	Posttest Experiment	.190	16	.126	.894	16	.065
	Pretest Control	.258	15	.018	.881	15	.059
	Posttest Control	.198	15	.119	.906	15	.117

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

The table shows the results of normality tests using the Kolmogorov-Smirnov and Shapiro-Wilk tests. In these tests, data are considered normally distributed if the significance value for both the Kolmogorov-Smirnov and Shapiro-Wilk tests is greater than 0.05.

The results of the Kolmogorov-Smirnov data normality test show significance values for each test group of 0.200, 0.126, 0.18, and 0.119, respectively. These values are greater than 0.05. The results of the Shapiro-Wilk data normality test show significance values for each test group of 0.468, 0.171, 0.094, and 0.156, respectively. These values are all greater than 0.05. All results from these two tests meet the requirements, indicating that the data obtained are normally distributed.

The homogeneity test was conducted using Levene's test with SPSS. The results of the homogeneity test can be seen in the following Table 3.

Table 3 - Test of Homogenleity of Varianlce

		Levene Statistic	df1	df2	Sig.
Student Learning Outcomes	Based on Mean	2.453	1	29	.128
	Based on Median	1.329	1	29	.258

Based on Median and with adjusted df	1.329	1	26.722	.259
Based on trimmed mean	2.516	1	29	.124

The results of the posttest data homogeneity test for both groups, the control and experimental classes, showed a significance value based on the mean of 0.128, greater than 0.05. This indicates that the posttest data for both groups were homogeneous.

To determine the overall improvement in student learning outcomes in the limited trial, a recapitulation of the pretest and posttest results for the experimental and control classes was conducted. The trial was conducted in the experimental class with a sample of 16 sixth-grade students from SDN 2 Brantaksekarjati. The control class, meanwhile, consisted of 15 sixth-grade students from SDN 1 Brantaksekarjati.

The average N-Gain score for the control group was 0.61, with an N-Gain (%) of 61. The average N-Gain score for the experimental group was 0.72, with an N-Gain (%) of 72. These results indicated that the experimental group achieved a high N-Gain score, classified as effective.

To find out the outline of the improvement of student learning outcomes in the extensive trial, a recapitulation of the pretest and posttest results was carried out on a wider sample, namely taken from grade VI students from 3 elementary schools, that is SDN 2 Brantaksekarjati with 16 samples, SDN 1 Brantaksekarjati with 15 samples, and SDN 2 Kalipucangwetan with 35 samples. With a total sample in the extensive trial of 66 students. The average N-Gain value of the first experimental class was 0.79 with N-Gain (%) was 79. The average N-Gain value of the second experimental class was 0.77 with N-Gain (%) was 77. The N-Gain value of the third experimental class was 0.78 with N-Gain (%) was 78. These results indicate that each experimental class has an N-Gain value with a high classification, with an effective category.

The independent sample t-test was used to determine whether the posttest mean differences between each test group were significant. A model is considered to have a significant mean difference if the sig (2-tailed) value is less than 0.05. The results of this test can be seen in the following table:

Table 4 - Result Uji t

		Levene's Test for Equality of Variances		**t-test for Equality of Means**							
						Significance				**95% Confidence Interval of the Difference**	
		F	**Sig.**	**t**	**df**	**One-Sided p**	**Two-Sided p**	**Mean Difference**	**Std. Error Difference**	**Lower**	**Upper**
Student Learning Outcomes	Equal variances assumed	6.032	.020	.804	29	.022	.044	2.021	2.512	3.117	17.159
	Equal variances not assumed			.816	25.748	.021	.042	2.021	2.477	3.074	17.116

The results of the independent sample t-test were conducted by examining the Equal Variances Assumed value. This was done because the data was homogeneous. The significance value obtained, or Sig (2-tailed), was 0.000 < 0.05. This means there was a significant difference in the average score between the experimental class posttest and the control class posttest. This finding is supported by the descriptive results of the independent sample t-test in the following table.

Table 5 - Statistical Results of Posttest Scores for the Control and Experimental Classes

	Kelas	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Hasil Belajar Peserta Didik	Posttest Ekperimen	16	84,66	8.260	2.065
	Posttest Kontrol	15	83,75	7.300	1.369

The table shows the experimental class' posttest average of 84.66 with a standard deviation of 8,260, and the control class' posttest average of 83.75 with a standard deviation of 9,300. This demonstrates a significant difference in averages. This means that learning using the developed teaching materials is significantly better.

The criteria for the effectiveness of the teaching materials are if the t-test result for the pretest score has a Sig. (2-tailed) value > α = 0.05; and the posttest score criterion is a Sig. (2-tailed) value < α = 0.05. After two trials, a posttest test was conducted to determine students' posttest learning outcomes. The t-test results for the posttest score obtained a

calculated t-value of 3.074 with a Sig. (2-tailed) value of $0.000 < \alpha = 0.05$. This means there is a difference in posttest learning outcomes in the control and experimental classes, that is that the posttest learning outcomes in the experimental class are higher than the control class. Thus, the interactive science flipbook teaching material assisted by articulate storyline3 has met the criteria for effectiveness (Arifinl, 2017:124). Therefore, it can be said that the e-module based on the smart app creator is effective in improving student learning outcomes.

4. Discussion

The analysis of the need for e-modules in grade VI elementary schools in the Gugus Melati at the Kecamatan Welahan, Kabupaten Jepara was conducted by conducting interviews, observations and documentation on teachers and students of grade VI in three public elementary schools in the Gugus Melati at the Kecamatan Welahan, Kabupaten Jepara. Field observations were conducted by researchers by interviewing grade VI teachers regarding problems in learning and regarding teachers' views on learning using digital media. The results obtained from these observations will be reviewed to determine the things needed in the initial ideas and content of learning materials that will be included in the development of e-modules based on smart apps creator. The initial concept for developing e-modules is an interactive, interesting, and easy-to-use learning application that contains material about the solar system that discusses two learning objectives, namely the first material about the planets in the solar system and the second material about the rotation and revolution of the earth and its consequences for life.

From the results of interviews from three elementary schools, that is SDN 2 Brantakasekarjati, SDN 1 Brantaksekarjati, and SDN 2 Kalipucangwetan, it can be concluded as follows: (1) The main learning resources used by teachers are only books and LPHS, teachers should be able to improve the quality of learning by developing teaching materials that are appropriate to 21st century learning, that is by utilizing technology. Teachers can develop interactive and interesting teaching materials to improve learning outcomes and student motivation by developing teaching materials that can be accessed via Android cellphones. Of the three elementary schools, on average, teachers only use videos from YouTube as learning media, conventional learning methods implemented in learning cause boredom in students so that interest in learning is low and results in decreased learning outcomes, (2) Schools need application-based e-modules that can be used to learn using Android cellphones so that they are easy for students to use to learn anywhere and anytime, with material content containing e-books, learning videos, equipped with games and quizzes to make it more interesting and fun, (3) All schools in Kecamatan Welahan already have an internet or wifi network, it would be better if students could utilize it by developing application-based e-modules.

The e-module design analysis was conducted through data collection, gathering various information that could be used as material for product planning, which is expected to address existing problems. The collected data was obtained from the needs analysis conducted in previous research.

In the design stage, the product was created in accordance with the needs analysis. The needs analysis was conducted through an analysis of the curriculum, learning outcomes (CP), learning objectives (TP), indicators, and learning materials, as well as data from teacher and student needs questionnaires. Based on these analysis results, an e-module on the solar system was developed based on the Smart Apps Creator (SAC). The product development process utilized several applications, including Heyzine Flipbooks, Canva, Wordwall, KineMaster, and Smart Apps Creator.

Feasibility analysis was conducted through design validation. Validation of the product design was conducted by expert validators to determine its feasibility based on the teaching materials, content, language, and practical aspects. Validation was conducted by lecturers who are experts in their fields. The researchers used lecturers from universities, namely teaching materials experts, material experts, and language experts from Muria Kudus University. For practitioners, the researchers used validators from elementary schools, namely school supervisors with master's degrees.

In addition to assessing the indicators provided in the questionnaire, the validators also provided input and suggestions. After revisions and improvements were made based on the expert suggestions and input, the product was declared feasible based on the feasibility scale, where a score of >71% indicates that the product is feasible. The validation results also indicate that the product is suitable as a supporting teaching material to assist sixth-grade students in understanding the solar system.

Based on the validation results carried out by teaching materials experts, a percentage of 80% was obtained with the "feasible" category, in the material validation, a percentage of 87% was obtained with the "very feasible" category, then in the language validation test results, a result of 97.5% was obtained with the "very feasible" category. Meanwhile, the validation results from practitioners obtained a percentage of 89% with the "very feasible" category. From these results, it can be concluded that the e-module on the solar system material is very feasible to be tested.

After expert validation was carried out with the category of "very feasible", the e-module product of the solar system material was tested on students and teachers. The product trial was carried out limitedly on sixth grade students of SDN 2 Brantaksekarjati as an experimental class with a total of 16 respondents. After the trial, researchers gave teacher and student response questionnaires to determine the feasibility of the teaching materials from the perspective of students and teachers. The results of the student response questionnaire analysis obtained a value of 87.18% and the product was included in the "very interesting" category. In addition to obtaining assessments from students, the product was also assessed from the perspective of teachers as instructors in the class. Based on the results of the teacher responses after

being averaged, it was known that the results of the teacher responses obtained a percentage of 92.33% with the category of "very interesting" teaching materials. This limited trial test stage was also carried out to measure the effectiveness of the e-module, namely by comparing it with a control class that implemented animal and plant reproduction learning without using an e-module. The control class determined by the researcher was SDN 1 Brantaksekarjati which consisted of 15 people.

The improvement of student learning outcomes is measured by the effectiveness of the product in learning. The improvement of student learning outcomes was analyzed using pretest and posttest data in a limited trial. The average pretest learning outcomes of the control and experimental classes were almost the same, namely 61.33 in the control class while 59.69 in the experimental class. After the re-test, the average posttest scores in the control and experimental groups increased to 84.67 and 86.88, respectively. Thus, the average increase in student learning outcomes in the control and experimental classes was 23.34 and 27.19, respectively. The average increase in learning outcomes in the experimental group was greater so it can be said that the e-module is effective in improving elementary school science learning outcomes. (Sugiyono, 2016: 204).

Student pretest and posttest learning outcomes were also analyzed using the N-gain test. The N-gain test results were obtained in the experimental class with an increase value of 0.72 in the high category, thus learning using e-modules based on smart apps creator has met the effective criteria (Sugiyono, 2018: 414).

The t test was also carried out using the SPSS program to test differences in learning outcomes in the control and experimental groups before and after the trial. The criteria for the effectiveness of teaching materials are if the t test results for the pretest score have a Sig value (2-tailed) > $\alpha = 0.05$; and the posttest criteria score is Sig. (2-tailed) < $\alpha = 0.05$. After 2 trials, a test was carried out to determine the students' posttest learning outcomes. The results of the t test for the posttest score obtained a calculated t-value = 3.074 with a Sig (2-tailed) value of $0.000 < \alpha = 0.05$. This means that there are differences in posttest learning outcomes in the control and experimental groups, namely that the posttest learning outcomes in the experimental group are higher than the control class. Thus, learning using e-modules based on smart apps creator (sac) has met the effective criteria (Sugiyono, 2018: 415).

After testing the effectiveness of teaching materials which was carried out in the sixth stage of the research and development steps from Borg & Gall, the research continued in the seventh step, namely product revision. Based on the results of student and teacher responses obtained from field trials, they were analyzed to determine the weaknesses of the teaching materials developed based on facts in the field. The results of the analysis are then used as revision material to maximize teaching materials, as well as to determine the effectiveness of the e-module. From the analysis of this data, the result was that the e-module product based on the smart apps creator (sac) that was developed was included in the "very interesting" category for use as learning teaching material and helped in the learning process, especially in science learning about the solar system. At this stage, there were no weaknesses found in the e-module. During initial testing, the only problem encountered was when installing the e-module application, there were several Android cellphones whose cellphone memory was almost full, so it took time to delete files to free up space.

The eighth stage is trial use, after testing the product is successful, and there may be some obstacles but do not interfere with the effectiveness of the e-module, the teaching materials can be applied to a wider scope, namely used for extensive trials in learning activities in three state elementary schools in Gugus Melati, Kecamatan Welahan Kabupaten Jepara with a total trial sample of 66 students. Extensive trials were carried out at SDN 2 Brantaksekarjati with a total of 16 students on Tuesday 6 February 2024, at SDN 1 Brantaksekarjati with a total of 15 students on Wednesday 7 February 2024, and at SDN 2 Kalipucangwetan with a total of 35 students on Thursday 8 February 2024.

The effectiveness of teaching materials is also measured in extensive trials. Improvements in student learning outcomes were analyzed using pretest and posttest data in extensive trials. The average pretest learning outcomes of the three experimental classes were almost the same, namely in the first experimental class it was 62.50; while in the second experimental class it was 61.33; and in the third experimental class it was 61.42. After testing, the average posttest score in each experimental class increased to 91.87; 90.66; and 90.57. Thus, the average increase in student learning outcomes in each experimental class was 29.37; 29.33; and 29.15. The average increase in learning outcomes in the experimental group was greater, so it can be said that e-modules are effective in improving student learning outcomes (Sugiyono, 2016: 204).

Student pretest and posttest learning outcomes were also analyzed using the N-gain test. The N-gain test results were obtained in three experimental classes with an average N-Gain of 0.79 in the first experimental class, 0.77 in the second experimental class, and 0.78 in the third experimental class. With the average N - Gain in the original experimental class ≥ 0.70, the e-module teaching materials were included in the high classification with the effective category, thus learning using solar system material e-modules based on the smart apps creator has met the effective criteria.

The ninth stage in the Borg & Gall step is product revision, at this stage no deficiencies were found. Because from the results of extensive testing, no problems or obstacles were found in using e-module teaching materials.

The tenth stage is mass production. Mass production was carried out by distributing the e-module application link to all class VI elementary school teachers in Welahan District, which consists of 48 elementary schools, through the Welahan District Class Teacher KKG forum and then forwarding it to all class VI students in each elementary school in Kecamatan Welahan with a total of 1,321 students for use in learning activities.

The development of an e-module in the form of an application that can be installed using an Android cellphone is expected to be able to meet students' learning needs and can be used anywhere and anytime. The e-module being developed certainly has advantages and disadvantages. The advantages of the e-module being developed include the learning material which is completely rounded, light and easy to understand because the material is rounded up based on facts and conditions in everyday life, equipped with pictures according to material on the solar system and equipped with fun learning videos, games and quizzes. Apart from that, operation is very easy because you just have to install it and then you can use it straight away. This e-module can be shared easily because it is based on an APK which can be shared via WhatsApp groups, so use can be done by sharing anywhere. The e-module can be accessed using an Android cellphone connected to the internet.

Based on this discussion, it can be concluded that the development of solar system material e-modules based on smart apps cerator (sac) has been proven to suit the needs of teachers and students, the design of teaching materials is in accordance with needs, and is suitable and effective for use in class VI elementary school learning.

CONCLUSION

Based on the results of the development research and the discussion that has been described, the conclusions that can be drawn are:

1. Analysis of the needs of teachers and students can be met by developing e-modules for solar system material based on class VI smart apps creators in three elementary schools in Gugus Melati, Kecamatan Welahan Kabupaten Jepara. So it can be said that the solar system material e-module based on the smart apps creator was developed according to the needs of class VI students and teachers at the school.
2. The development of e-module design for solar system materials based on smart apps creator was developed through curriculum analysis, learning outcomes (CP, learning objectives (TP), and indicators were developed using smart apps creator, namely software for creating e-module applications. Apart from that, other supporting applications for e-module development are Heyzine Flip HTML, Canva, Wordwall, and Kinemaster. E-modules can be accessed using any type of Android cell phone that is connected to the internet.
3. The feasibility of e-module teaching materials was obtained based on the percentage of expert validation, namely: teaching materials experts at 80% in the "feasible" category, material experts at 87% in the "very feasible" category, language experts at 97.5% in the "very feasible" category, and practitioner validation at 89% in the "very feasible" category. Furthermore, feasibility was also measured from the results of student responses of 87.18% with the product category "very interesting" as teaching materials and responses from teachers in three elementary schools with an average of 92.33% with the product category "very interesting".
4. The effectiveness of e-module teaching materials was obtained from the average learning outcomes in limited trials through the results of the pretest for the control and experimental classes, namely the pretest in the control class was 61.33 while in the experimental class it was 59.69. After testing, the average posttest score in the control and experimental groups increased to 84.67 and 86.88. In this way, there was an increase in the average student learning outcomes in the control and experimental classes so that the e-module was declared effective. Effectiveness was also measured in extensive trials with an average N-Gain of 0.79 in the first experimental class; 0.77 in the second experimental class; and 0.78 in the third experimental class. The increase in average learning outcomes in the experimental group shows that e-modules are effectively used in learning in class VI elementary school.

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Conflict of Interest

The authors declare no conflicts of interest.

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