Gema WIRALODRA

Editor-in-Chief: Yudhi Mahmud

Publisher: Universitas Wiralodra

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Abstract
This research aims to 1) produce PBL-Based E-Modules with a STEM approach that meets the eligibility criteria, and 2) determine the effectiveness of PBL-Based E-Modules with the resulting STEM approach to increase the learning motivation of grade VI students of SD Sekecamatan Piyungan. This research is Research and Development (R&D) using the ADDIE model which consists of analysis, design, development, implementation, and evaluation. Product feasibility tests are carried out by media expert validators and material expert validators. The subjects of the one-to-one trial were three students and 1 teacher at SD Muhammadiyah Karangploso. The subjects of the small group trial were 23 students of SD Negeri Piyungan Class A. The subjects of the field trial were 25 students of SD Negeri Piyungan class B as the control class and 27 students of SD Negeri Mandungan as the experimental class. Data collection using interview guidelines, observation guidelines, product assessment sheets, teacher response scales and student response scales, and learning motivation scales of grade VI elementary school students were analyzed using a t-test. The results of the study showed that: (1) The PBL-based e-module with the resulting STEM approach met the criteria of "Very Feasible" according to the assessment of media experts and subject matter experts, in the one to one trial obtained the category of "Very Feasible" from the responses given by the teacher and obtained the category of "Feasible" from the students' responses, while in the small group trial obtained the category of "Very Feasible" from the responses given by the teacher and obtained the category of "Feasible" from the responses of the students; (2) PBL-based E-Module with a STEM approach in significantly increasing the learning motivation of grade VI elementary school students with a significant score of $0.000 < 0.05$
Keywords: E-Module, *Problem Based Learning*, STEM, Learning Motivation.

1. Introduction

Education is important for the progress of a nation. Indonesia is a developing country with a very large population. (Badan Pusat Statistik, 2023) recorded that until the middle of the month in 2023, the number of Indonesia's population reached 278 696.2 people. Indonesia's rich natural resources and human resources must be able to play a role in the development of science and technology around the world. However, the fact proves that globalization brings enormous challenges to education in Indonesia, such as challenges in the learning process. Learning is needed to grow a generation of countries that are competitive and superior in human resources and have the skills needed to survive in the 21st century.

Entering the era of the industrial revolution 4.0, education, especially in science learning, has a responsibility to create intelligent, responsible, and adaptive human beings Arnyana (Zulaiha & Kusuma, 2020). Mastery of the basics of science and mathematics is also believed to be a must for every individual living in the 21st century. According to (Hidayat et al., 2019) In the 21st century, it is increasingly important to ensure that students have learning and innovation skills, skills in using technology and information media. Therefore teachers It is required to be able to choose the learning method that will be implemented in the classroom to

activate students, provide varied teaching materials, and choose learning media that can awaken students in absorbing information and fostering motivation in learning.

According to (Sari et al., 2021) Motivation is a psychological impulse which is a change in energy in a person to continue to be enthusiastic and persist to do something in accordance with the direction and goals he wants to achieve both consciously and unconsciously. The essence of motivation to learn according to (Sari et al., 2021) is the impulse that influences students who are learning to change their behavior can be identified through several indicators or supporting factors. These indicators of learning motivation can be classified as follows: the existence of internal motivation, such as the desire and desire to succeed, the motivation and needs that encourage learning, hopes and aspirations for the future, rewards obtained through learning, interesting learning activities, and the existence of a conducive learning environment that can motivate students. In addition to motivation in learning, the ability to think at a higher level is important.

One of the high-level thinking skills is problem-solving skills. The ability to solve problems functions in providing solutions or solutions innovatively in facing global problems, so that problem-solving skills are one of the benchmarks that should be possessed by 21st century students in order to be maximally competitive. However, Indonesia's readiness still seems to require a special strategy. This can be seen from Indonesia's ranking based on TIMSS (Trends International Mathematics and Science Study) and PISA (Program for International Student Assessment) data at the end of 2022. Low TIMSS and PISA results show that Indonesian students do not know the questions that require a high-level perspective. for 15 years in a country with a low level of science proficiency IES (Hidayat et al., 2019) The low level of problem-solving ability in Indonesia also occurs in some elementary schools in Yogyakarta, namely elementary schools in Piyungan District.

Based on the results of observations conducted in August 2023 at an elementary school in Piyungan District, the Principal said that in general, students began to experience difficulties in learning, the factors causing learning difficulties included internal factors in the form of learning motivation, learning interests, and learning habits, as well as external factors including the environment, learning models, teaching materials, teaching materials and so on, but learning difficulties in students were only temporary. Meanwhile, the teacher also conveyed that the material still uses teaching materials that have not been able to improve problem-solving and motivate students.

In addition to the use of teaching materials and learning media to help students receive materials, other methods can also be used, namely with a learning model. (Hanafiah et al., 2009) revealed that the learning model is one of the approaches in order to work around changes in student behavior in an adaptive and generative manner. The learning model is an approach used by teachers in the learning process in the classroom that pays attention to students' initial knowledge and directly involves students about activities, skills, attitudes, and knowledge. Although various studies have shown that Science, Technology, Engineering, and Mathematics (STEM) and Problem-Based Learning (PBL) approaches can improve students' critical thinking, collaborative, and motivational learning skills, most of these studies still focus on the context of learning in urban schools with adequate facilities or in the realm of specific exact subjects. There have not been many studies that have examined the effectiveness of integrating STEM and PBL in the context of science. In addition, the use of STEM-PBL-based e-modules is also relatively new and has not been widely explored in terms of practical implementation and its influence on student learning motivation. Most of the e-modules developed still emphasize the content aspect, not on how the modules can facilitate problem-solving approaches and inter-disciplinary integration as characteristic of STEM learning. Thus, there is still a research gap related to the application of the STEM-PBL integrative approach combined
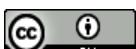
with the use of e-modules in the context of science. This research aims to fill this gap by examining how the application of STEM-PBL-based e-modules can increase students' learning motivation

E-modules are a new breakthrough in the world of education in the 21st century, where in education in the 21st century, innovative schools are schools that have used technology and pedagogical approaches that will be increasingly common in the future Hanover (Fitriyani, 2020). It is not enough just to combine technology, 21st century education must also be accompanied by a learning approach that can include various aspects, both technology and mathematical principles. STEM (*Science, Technology, Engineering,* and *Mathematic*) is a popular learning model around the world, as it combines the four main areas of education, namely science, technology, engineering, and mathematics, so that it can effectively implement comprehensive learning (Amir & Purwanti, 2021). (Sumarni et al., 2019) stated that the approach of the four aspects is a harmonious pair between problems that occur in the real world and also problem-based learning (Problem Based Learning).

Problem Based Learning (PBL) is a learning model designed to give students essential knowledge that makes them proficient in problem solving, and to have their own learning model and to have the ability to participate in teams (Djaga et al., 2022). In chemistry education where students often struggle with abstract concepts PBL provides opportunities to construct conceptual understanding through dialogue, inquiry, simple experimentation, and connecting theory with real-world applications (Arifiani et al., 2025). PBL and STEM models can create cohesive learning systems and active learning. This is because in the STEM method there are many aspects that are considered to improve students' problem-solving skills, namely *science, technology, engineering,* and *mathematical*.

Learning aids have a role in making it easier for teachers to deliver material to students during learning. The creative and innovative use of media has a great effect on the ease of students in understanding the subject matter. In the material Characteristics of Animals, Plants, and Habitats, using E-Modules Based on Problem Based Learning with a STEM Approach to develop students' motivation. Therefore, the researcher intends to conduct a research entitled "Development of Problem-Based Learning E-Modules with a STEM Approach to Increase the Learning Motivation of Class VI Elementary School Students in Piyungan District". Thus, the researcher hopes that there will be a learning process of Problem-Based Learning modules with a STEM approach so that the level of problem-solving and student motivation increases.

2. Method

a. Types of Research

This research uses the type of R&D (*Research and Development*) development research. In this development research, the researcher used the ADDIE (*Analyzing, Designing, Developing, Implementing, and Evaluating)* development model. The ADDIE model has evaluation activities for development activities at each stage (Branch, 2009). This research aims to 1) produce PBL-Based E-Modules with a STEM approach that meets the eligibility criteria, and 2) determine the effectiveness of PBL-Based E-Modules with the resulting STEM approach to increase the learning motivation of grade VI students of SD Sekecamatan Piyungan.

b. Research Subject

The subjects of the one-to-one trial were three students and 1 teacher at SD Muhammadiyah Karangploso. The subjects of the small group trial were 23 students of SD Negeri Piyungan Class A. The subjects of the field trial were 25 students of SD Negeri Piyungan class B as the control class and 27 students of SD Negeri Mandungan as the experimental class.

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c. **Data Collection Techniques and Instruments**

Data is an important element that supports in answering questions, testing hypotheses, and achieving research objectives. The type of data used in this study is primary data. The techniques used in data collection are interviews, questionnaires, and tests. Interviews in this study were conducted with the intention of obtaining information to analyze the needs as a basis for research and development of E-modules. The questionnaires used in this study are validity questionnaires and practicality questionnaires. In this study, the distribution of validity questionnaires will be given to validators, namely media experts and material experts. Practicality questionnaires will be given to teachers and students. The test questions used are in the form of description questions consisting of 11 questions. Data collection through this test question was carried out during the effectiveness test before and after the use of media.

d. **Data Analyst Techniques**

Product Eligibility

The data analysis carried out in this development is descriptive statistics. Descriptive statistics are used to describe and analyze respondents' responses from the questionnaire that has been given (Hartono, 2019). To find out whether the media is valid or not, the weight of each response obtained from the questionnaire will be calculated. Validation data analysis is carried out to find out whether the developed product is feasible to proceed to the next stage. The analysis of the feasibility data of E-module products is carried out by collecting all data based on assessments by media validators and material validators (quantitative data). After the data is collected, the data is input and converted according to the range or score interval, then criteria are given qualitatively using a likert scale to easily impregnate the data when determining the feasibility of the E-module product developed. The formula used to calculate validator eligibility is as follows:

$$X = \frac{\Sigma x}{n}$$

Table 1.
Eligibility Criteria for Media Members and Material Members

Interval Score	Kategori
$3.25 < \bar{x} < 4.00$	Very Worthy
$2.50 < \bar{x} < 3.25$	Worthy
$1.75 < \bar{x} < 2.50$	Not Feasible
$1.00 < \bar{x} < 1.75$	Very Unworthy

The next stage is to calculate the percentage of the practicality test. The formula for the practicality test is as follows:

Product Effectiveness Analysis

Learning motivation data was analyzed to see test score using N-gain. It is written with the following equation:

$$\text{Std gain} <g> = \frac{x\,post\,test - x\,pretest}{x - xpretest}$$

The results of the data calculation on the gain score value are then interpreted into the appendage (g) in table 2.

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Table 2.
Gain Score Criteria

No.	Nilai Gain	Criterion
1	$g \geq 0,70$	High
2	$0,30 \geq g < 0,70$	Medium
3	$g < 0,30$	Low

Furthermore, the technique used in analyzing the data is the independent samples t-test to see the significance of product use. The hypothesis test using an independent sample t test is to find out whether or not there is a difference in learning motivation in students who use e-modules, and those who do not use e-modules.

3. **Results and Discussion**

The e-module was developed according to the ADDIE model. The stages of the ADDIE model consist of five stages, namely *analysis, design, development, implementation,* and *evaluation*. The stages of product development start from the analysis of the need for media, the analysis of media needs according to the characteristics of the students and the analysis of the curriculum used in schools. At the needs analysis stage, interviews were conducted with 3 teachers from 3 elementary schools in Piyungan District. Based on the interviews conducted, information was obtained that the school has not yet innovated in the e-module. Science learning in schools is still always centered on textbooks. Then the school has also never used a digital science book.

After interviews with several classroom teachers, the researcher analyzed the curriculum used by the school. The curriculum analysis carried out in this study is adjusted to the curriculum used by the school. The schools used as the subject of the study used the 2013 curriculum. The material discussed in the e-module media is about the characteristics of animals, plants, and their habitats.

The next stage is design in developing e-modules, this design includes making sketches of book drawings, coloring sketches, and compiling book systematics. Then the next stage *is the* development stage which includes the preparation of teaching materials. Activities of collecting teaching materials/materials, making illustrations, typing, and others are in the development stage. At this stage the author develops the work in each learning, the E-Module will be revised by several experts such as media experts and material experts. The validation of e-mdoul products in this study was carried out by 1 lecturer by a media expert and 1 lecturer by a material expert.

After 2 repairs were made according to media experts. The results of media expert assessments can be reviewed from several aspects, namely the feasibility of content, language, presentation, and graphics. the results of the assessment of media expert validators on the PBL-Based E-Module with a STEM approach with an average score of 3.35. Thus, it can be concluded that the "Very Feasible" E-Module is used according to media experts. Material experts consisting of lecturers reviewed the e-module from several aspects, namely the completeness of the e-module components, the suitability of the content for learning and effective and efficient language according to the assessment of material experts that the score obtained from the results of the E-module validation was 3.71 so that it was included in the category "Very Feasible". The categories obtained can be concluded that the E-module is categorized as Very feasible to be field-tested to students with revisions.

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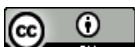
Figure 1.
Science E-Module Products
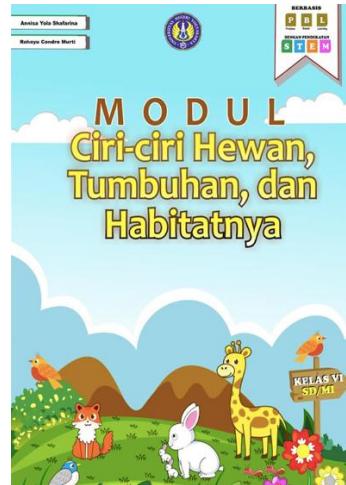
Media practicality tests in this study were carried out in one-to-one trials, small-scale trials, and large-scale trials. The One to One trial was carried out on 3 elementary school grade VI children. Based on the results of the One to One test stage, it can be concluded that students like the appearance of this e-module. The material presented is also easy for students to understand. Students also easily understand and understand how to use e-module media. Students are also enthusiastic and happy if this media is used by teachers in science learning. This e-module media has an attraction for students because it can make science learning more fun. Small-scale trials were carried out on 3 children in class VI. Based on the results of the calculation of the media practicality test from 3 children, an overall score of 31 and an average score of 10.3 were obtained. The results are in the very practical category.

The small group trial was carried out by 23 grade VI students and 1 class teacher. Based on the results of the assessment of the student response questionnaire in the small group test, the overall score was 245 and an average score of 10.6. The results are in the Very Practical category. In addition to filling out the response questionnaire, students also had the opportunity to provide comments and suggestions regarding the interactive E-module. The comments from students regarding the aspects that exist in the media, namely: (1) E-modules are very interesting (2) E-Modules are good at creating enthusiasm for learning. (3) E-modules make me happy. Then for the results of the media practicality test from grade VI teachers, the overall score is 37 and an average of 3.7 is in the "Very Practical" category. In addition to filling out questionnaires, teachers also have the opportunity to provide comments and suggestions about the E-module. The suggestions and comments from teachers regarding the aspects in the media are: Overall, the E-Modules made are good. The choice of words is good, easy for elementary school students to understand. The display of the E-Module is also quite interesting, so students don't get bored easily to learn.

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Figure 2.
Results of the Comparative Recapitulation of Teacher and Student Response Questionnaires
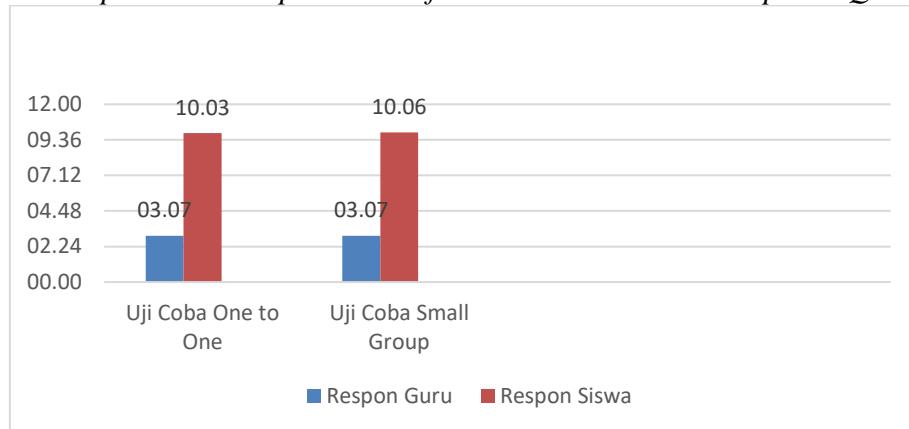
Based on the results of the data diagram above, it shows that there is an increase in the results of the assessment of student response questionnaires to the assessment between the one to one trial and the small group test. The first trial, namely One to One, experienced an equation in the teacher's response score of 3.7, in the small group trial, the teacher's response had a score of 3.7. Meanwhile, in the Response, students experienced an increase between the one to one trial and the small group test, where the one to one test received a score of 10.3 and an increase in the small group test to 10.6. Thus, the score equation in the teacher's response is 37 points. Then in the student response, which is 0.3 points. Based on the assessment of the teacher and student response questionnaire, the two teachers in the one to one trial and the small group trial provided comments and suggestions about the E-modules that had been tested. Broadly speaking, the teacher's comments are an attractive E-module display, the language is easy to understand, with the existence of barcodes/learning videos making it easier for students to gain general knowledge. Meanwhile, comments from students generally say that students feel happy learning using e-modules because they can learn using cellphones.

Furthermore, to see the extent to which students' learning motivation increases in kntrol classes and eating experiment classes, N-Gain calculations can be performed. The results of the N-Gain calculation can be seen in table 3 below.

Table 3.
N-Gain Calculation Results

No	Class	Mumber of Students	Score of Motivation		Gain	Category
			Before	After		
1.	Control	25	28,74	57,17	0,47	Medium
2.	Experiment	27	31,27	81,27	0,72	High

In table 3, it can be seen that the control class obtained a motivation score before treatment of 28.74 while the motivation score after treatment was 57.17 with a gain value of 0.47 in the medium category. The experimental class obtained a motivation score before treatment of 31.27 while the motivation score after treatment was 81.27 with a gain value of 0.72 in the high category. To be clearer, the increase in learning motivation scores in control classes and experiments before and after learning is presented in the following diagram 2:

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Figure 3.
Comparison of Learning Motivation
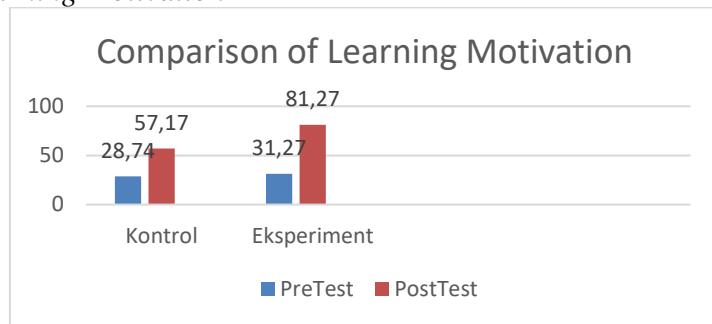
Comparison of Learning Motivation Results Based on diagram 2, it can be seen that the control class obtained the lowest average score on the pretest and posttest in learning motivation. The highest average score of the learning motivation pretest was obtained by the experimental class. Furthermore, to draw conclusions from the hypothesis test, whether or not there is a difference in the average ability of students between the control class that uses the media of the lks book and the experimental class that uses the media of the e-module. Independent samples t-test using SPSS version 23 application. When the value of sig. > 0.05 then H0 is accepted and Ha is rejected, then if sig. < 0.05 then H0 is rejected and Ha is accepted. The following is the hypothesis tested for the numeracy literacy variable. The results of the independent sample t-test can be seen in table 4.

Table 4.
Independent Sample T-Test Results

Class	Sig. (2-tailed)	Information
Experimental class-control class	0.000	There are differences

Based on the results of the independent sample t-test, the value of sig. obtained by $0.000 < 0.05$, meaning that Ha is accepted and H0 is rejected. It can be concluded that there is a significant difference between the average score of students who use e-modules and those of classes who use LKS books.

The variable that is seen to be effective in the use of E-module teaching materials is learning motivation. Motivation is the drive or desire to achieve a goal that has been planned with effort and tenacity (Schunk et al., 2012:475). The results of the analysis of student learning motivation prove that E-modules are effective in increasing student learning motivation. According to (Firdaus et al., 2024) With the module, it can increase students' motivation to learn so that they are more active and interested in participating in the learning process. The availability of the right teaching materials will greatly affect the achievement of learning objectives (Mustadi et al., 2024). The results of the questionnaire showed that the increase in student learning motivation in the experimental trial class was higher when compared to the control class. The increase in the value of student learning motivation is seen from the average score in the experimental trial class before and after participating in learning using e-modules. This can be seen from the average score of the test results and the gain value in the pretest and posttest in the experimental class is higher than in the control class.

In addition, based on the results of the t-test, it shows that E-modules are declared effective in increasing students' motivation to learn. The results of the paired t-test analysis proved that there was a difference in students' learning motivation before and after using the E-module product with a sig value. < 0.05, which is 0.000. The results of the independent t-test also proved

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that there was a difference in student learning motivation between students who studied using E-modules and students who did not use E-modules with sig scores. < 0.05 which is 0.000. Increasing student learning motivation can occur due to several things, namely: the content component of the E-module, easy to use anywhere, the stimulus-responses contained in the media make students enthusiastic and active. This is in line with research conducted by Oksa & Soenarto (2020) showing that e-modules are very feasible and effective to be used to increase learning motivation in students.

4. Conclusion

This e-module media product is suitable for use as a medium with material on the characteristics of animals, plants, and their habitats for grade VI of Elementary School. This is seen from the results of the validation of media experts with a score of 3.35 and material experts with 3.71 with the category "Very Feasible". The e-module media product in this study is practically used as a medium with material on the characteristics of animals, plants, and their habitats for grade VI of Elementary School. The e-module media product is quite effective as a medium with material on the characteristics of animals, plants, and their habitats based on the results of the n-gain calculation and based on the independent sample t-test there is a significant difference between the average score of students who use e-modules and students who use LKS books.

Based on the conclusion regarding the development of this e-module product, it is recommended to teachers to use this e-module media as an alternative to science learning companion books, especially to be used as a medium with material on the characteristics of animals, plants, and their habitats for grade VI elementary school students.

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