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DEVELOPMENT OF PBL MODEL SCIENCE E-MODULES TO IMPROVE PROBLEM-SOLVING SKILLS IN STATIC ELECTRICAL MATERIALS

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Abstract: This study aims to develop a science e-module through the Problem Based Learning (PBL) model on Static Electricity material and test its effectiveness on the problem-solving skills (KPM) of grade IX students. The method used is Research and Development (R&D) with the ADDIE model (Branch, 2009). The research subjects were 30 students of class IX A SMP Negeri 11 Mimika. The instrument is in the form of a 11-item KPM test (Arikunto, 2010). The analysis technique used n-Gain descriptive analysis of percentages and categories on the Likert scale (Hake, 1999). The results of the study showed: (1) E-modules were declared very feasible to use with an average material feasibility of 97.68%, media feasibility of 96.72%, teacher response of 98.33%, student response of 96.39%, and the average overall feasibility of e-modules based on validator assessments of 96.80% (Ministry of National Education, 2008). (2) The e-module effectively increased KPM with an average pre-test of 38.98 to 71.98 in the post-test and n-Gain of 0.54 in the medium category. Conclusion: the PBL model science e-module is feasible and effective in improving students' problem-solving skills in Static Electricity material.
Keywords: e-module; Problem Based Learning; problem-solving skills; static electricity.

1. INTRODUCTION

21st century education requires students to have high-level thinking skills, one of which is problem-solving skills (KPM) (Siregar, 2021). The Independent Curriculum emphasizes that learning must be oriented towards the development of competencies and character through a meaningful approach (Ministry of Education and Culture, 2022). However, the results of observations at SMP Negeri 11 Mimika show that students' KPM in Static Electricity material is still low. The teaching materials used are still limited to printed books and lecture methods that do not train students to solve contextual problems (Ministry of National Education, 2022). Even though Static Electricity is an abstract material that is closely related to everyday phenomena such as lightning and electroscopes (Nuari, 2021; Yunita Widyaningsih, 2022), so it requires media that is able to visualize concepts so that they are clearer and easier for students to understand (Zubaidah et al., 2018). It is necessary to apply a learning approach that makes students not bored and bored, but they will be enthusiastic and motivated to learn. Teacher-centered learning needs to be changed to stimulate students to be inspired, motivated, and active in their learning activities. Learning is not just about taking notes, memorizing, and doing problems without a meaningful and memorable learning experience. Students need to be actively involved in learning activities so that they can build their own understanding through the activities carried out.

KPM is not only relevant in the context of science education, but is also widely recognized by legal practitioners. Peter Mahmud Marzuki (2005) emphasized that legal research is essentially a "know-how" activity, namely analyzing the problems faced and then providing solutions to the problems rather than just "know-abouts". In practice, after an event is identified as a legal problem, concrete events are qualified as legal events, and then legal problem solving is sought through applicable legal regulations. This shows that problem-solving skills are cross-field and are fundamental competencies that need to be built from the basic education level. The urgency of the development of KPM is in line with the mandate of Law No. 20 of 2003 concerning the National Education System Article 3, which states that national education aims to develop the potential of students to become knowledgeable, capable, creative, independent, and responsible human beings. In line with that, Article 31 Paragraph 1 of the 1945 Constitution emphasizes that every citizen has the right to education, including education that equips high-level thinking skills such as problem solving.

One of the solutions that can be applied is the use of e-modules in learning. The development of the Problem Based Learning (PBL) model e-module on static electrical materials is expected to improve students' problem-solving skills and learning outcomes. This e-module is expected to be an innovative solution in science learning that not only improves student learning outcomes, but also trains students to think critically, improve problem-solving, creative, and independent skills. This research is also expected to make a positive contribution to the development of digital teaching materials that are more effective and relevant to the needs of students in the modern era. The development of the Problem Based Learning (PBL) e-module on Static Electricity material is expected to be an innovative, effective, and efficient solution in improving problem solving skills and student learning outcomes.

E-modules are digital teaching materials that are systematically arranged, containing text, images, animations, and videos so that they can be learned independently (Oktavia et al., 2018; Hutahaean et al., 2019). The Problem Based Learning (PBL) model has the main characteristics of starting with real problems as learning triggers (Barrows, 1998; Boud & Feletti, 1997). The syntax of PBL includes problem orientation, learning organization, investigation, outcome development, and evaluation (Stepien et al., 1993; Ibrahim & Nur, 2004), so that it is relevant to train MOE students (Gredler, 2001; Trianto, 2010; Arends, 2012).

Several previous studies have proven that PBL e-modules are effective in improving students' problem-solving skills, such as the research of Islahiyah et al. (2022) and Widyastuti and Triana (2024) which proved that PBL e-modules are effective in improving students' problem-solving skills.

Based on this background, this study aims to: (1) develop a PBL model science e-module on Static Electricity material that is feasible, and (2) analyze the effectiveness of e-modules on increasing KPM of grade IX students of SMP Negeri 11 Mimika.

2. RESEARCH METHODS

This research uses Research and Development (R&D) with the ADDIE model: Analysis, Design, Development, Implementation, Evaluation (Branch, 2009). The analysis stage is carried out to identify learning needs, student characteristics, and problems related to collaboration skills. The Design stage includes the preparation of the e-module structure, display design, and the development of research instruments. In the Development stage, e-modules are made, validated by experts, and product revisions. The Implementation stage is carried out through limited trials and extensive field trials in science learning in class IX. The Evaluation stage is carried out in a formative and summative manner to assess the feasibility and effectiveness of the e-module in improving student KPM.

The research was carried out at SMP Negeri 11 Mimika in February 2026. The research population is all grade IX students of SMP Negeri 11 Mimika. The e-module instruments developed before use were validated by 3 material experts, 3 media experts, 3 science teachers, and 9 grade 9 students in a small-scale trial. The KPM test instrument was first tested for validity and realism to 30 students in other classes before being used in the research class. The subjects in the study used 30 students of class IX A for a large-scale test and 9 students of class IX B for a limited scale e-module. The validity and reality test of the questions used 30 students of class IX G. The research sample was selected by purposive sampling. The research design used One Group Pre-test-Post-test Design. The research variables consist of an independent variable, namely the PBL model e-module, and a bound variable, namely Problem Solving Skills. The data collection instrument was in the form of a KPM test with 11 questions and descriptions given at 3 meetings with indicators of identifying problems, formulating hypotheses, collecting data, analyzing, and concluding (Arikunto, 2010).

The feasibility of e-modules is analyzed descriptively as a percentage with eligibility criteria according to Table 1.

Table 1. E-Module Eligibility Criteria

Eligibility Percentage	Categories	Remarks
81% - 100%	Highly feasible	Okay, no revision needed
61% - 80%	Worthy	Good needs revision
41% - 60%	Quite Decent	Pretty good, revision and review of the content of the material

0% - 40%	Not eligible	Not good, total revision and reassessment of the content of the material

Source: Arikunto, 2002

The measurement of students' pre-test and post-test problem-solving skills (KPM) improvement was carried out through the analysis of the n-Gain (normalized gain) test with the equation:

$$\text{n} - \text{Gain} = \frac{\text{Posttest} - \text{Pretest}}{\text{skormaksimum} - \text{pretest}}$$ (Hake, 1999).

The high and low normalized n-gain values can be classified in Table 2.

Table 2. Normalized n-Gain Values

G Value	Category n-Gain
$g > 0,7$	Height
$0,3 \leq g \leq 0,7$	Medium
$g < 0,3$	Low

Source: Hake, 1999

Categorization to determine the ability to improve students' KPM using the criteria in Table 3.

Table 3. Criteria for Pupil MOE Improvement

Percentage (%)	Categories
80-100	Excellent
66-79	Good
56-65	Enough
40-55	Less
≤ 39	Very Less

Source: Arikunto, 2009

3. RESULTS AND DISCUSSION

This research produced a product in the form of an e-module on Static Electricity material through the Problem Based Learning model to improve Problem Solving Skills at SMP Negeri 11 Mimika. The development of E-modules is adjusted to the Learning Objectives Flow (ATP) and the Teaching Module of the independent curriculum. This e-module is designed interactively using the Heyzine Flipbooks application in Canva.

The e-module is comprehensively structured and consists of several main sections:

a. Opening Section: Cover, introduction, table of contents, list of images/tables/links, concept map, and instructions for use.

b. Core Sections: Introduction, Learning Objectives, Learning Goal Achievement Indicators (IKTP), explanation of prerequisite concepts, content of materials, learning videos, and Student Worksheets (MFIs).
c. Evaluation & Closing Section: Pre-test and post-test questions, answer keys, glossary, bibliography, and author biodata.

After the development and preparation stages of the e-module components are carried out, the next step is the validation process and implementation in the classroom. It aims to measure the quality of the product and its effectiveness in improving students' collaboration skills, with the following results:

E-Module Eligibility

Before being implemented, the e-module was validated by 3 material experts, 3 media experts, validated by 3 science teachers and 9 students. The recapitulation of the validation results by validators is presented in Figure 1.

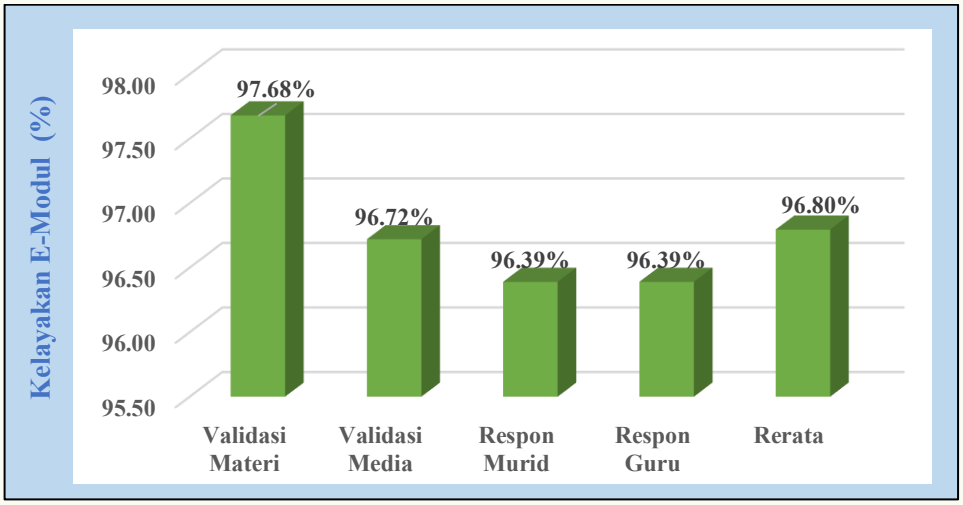

Figure 1. E-module eligibility percentage graph

The results of the e-module validation in Figure 1 show that the static electrical science e-module is very feasible to be used as teaching material, with the following feasibility specifications: 97.68% material validation (very feasible), 96.72% media validation (very feasible), 96.39% student response (very feasible), and 98.33% teacher response (very feasible). Overall, the percentage of e-module e-module eligibility scores reached 96.80%, which placed it in the category of very feasible for use in science learning. The feasibility aspect of content is 95% because the material is in accordance with the CP and contains contextual examples of lightning (Nuari, 2021). The media aspect is 94% after the revision of the electroscope image resolution (Yunita Widyaningsih, 2022). This is in line with the Ministry of National Education (2022) that modules must facilitate independent and contextual learning.

The Effectiveness of E-Modules on Problem-Solving Skills

The results of the KPM test before and after using the e-module are presented in Table 4.

Table 4. Average N-Gain Score of KPM Pupils

Learning	Average Score		n-Gain	Categories
	Pre-test	Post-test		
Teaching Module 1	38,67	68,00	0,48	Medium
Teaching Module 2	37,44	70,51	0,53	Medium
Teaching Module 3	40,83	77,44	0,62	Medium
Average	**38,98**	**71,98**	**0,54**	**Medium**

Table 1 shows that the average KPM increased by 33.00 points from 38.98 to 71.98. The n-Gain value of 0.54 belongs to the medium category. The highest increase occurred in the indicators "formulating a hypothesis" and "determining a solution". This is because the PBL syntax in the e-module leads students to analyze videos of lightning phenomena, conduct investigations through PhET simulations of electrical charges, and then solve problem-based digital MFIs.

PBL provides an authentic learning experience because problems become the starting point for learning (Barrows, 1998; Stepien et al., 1993). The PBL stage trains KPM indicators systematically (Arends, 2012; Ibrahim & Nur, 2004). These results are consistent with Dana et al. (2025), Widyastuti and Triana (2024), and Islahiyah et al. (2022) that PBL e-modules are effective in practicing problem-solving.

4. CONCLUSIONS AND SUGGESTIONS

CONCLUSIONS

The PBL model science e-module on Static Electricity material developed through the ADDIE model was declared very feasible with an average feasibility of 96.80% and was effective in improving students' problem-solving skills with n-Gain of 0.54 medium category.

SUGGESTIONS

Developing PBL model e-modules that are relevant to daily life as one of the learning resources that are tailored to the needs of students, so as to increase their interest and motivation to learn. The application of learning needs to be made flexible to achieve learning goals, both online and offline. The use of learning facilities remains under the supervision of teachers so that students do not abuse them during the learning process.

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