Development of E-Modules on Problem-Based Learning to Enhance Students Science Literacy

Asnidar¹, Safriana², Saifuddin Muhammad Jalil³, Halimatus Sakdiah⁴, Syarifah Rita Zahara⁵

¹, ², ³, ⁴, ⁵Department of Physics Education, Malikussaleh University, North Aceh - Indonesian

INTRODUCTION

Education is a place to seek knowledge for students structured in an education system. In education, there is interaction between teachers and students who reciprocally study a field of science. A coherent education system can be a benchmark for students' success in understanding a problem and material the teacher presents (Athurra & Kaffenberger, 2022). The development of science in education in the current digital era requires teachers to utilize technological advances to play an active role in transferring learning materials to students optimally. Teachers are expected to be able to shape learning to be more fun through a variety of skills and creativity students need to participate in learning (Kimianti & Prasetyo, 2019). In the process of achieving these goals, the government, through curriculum development, began to implement various integrations in it, including literacy.

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ABSTRACT

Interactive electronic modules are teaching materials used in the learning process with the help of today's technology which is useful for forming a more creative learning process. This development research method refers to Research and Development (R&D) with the ADDIE model. The research subjects were 11th-grade Science 4, totalling 31 students and the research objects were located at Kejuruan Muda Public High School 1. Data collection instruments in the form of pretest and post-test and an interest questionnaire regarding the e-module. Data analysis is qualitative data analysis and quantitative data analysis. The results obtained are from material experts in the "Decent" category, while validation results from media experts are in the "Decent" category. the results of the teacher's response in the "Very Interesting" category and the results of the student's response in the "Very Interesting category. The N-gain test carried out in 11th-grade Science 4 obtained a result of 0.70 with a percentage of 70% falling into the "High" category. The results of this research indicate that the development of an interactive electronic module based on problem-based learning on material elasticity of materials and Hooke's law is suitable for use and can increase students' scientific literacy.
skills, science skills, attitude skills, and the ability to master technology, so that it is necessary to increase literacy skills as a solution in developing knowledge and soft skills in the current era of technological development through the independent curriculum (Pakpahan, 2022).

The Ministry of Education and Culture compiles an independent curriculum regarding intracurricular learning that makes learners more independent and conceptual and can improve their abilities through interactive learning (Kemendikbud, 2022). Through the independent curriculum, students are formed into individuals with good competence and an open personality about science who can think logically, critically, creatively, argue correctly, communicate well and collaborate well through science literacy (Nadir et al., 2022).

The Organization for Economic Co-operation and Development (OECD) states, “Science Literacy is a form of science and scientific skills to identify and analyze various questions presented. Through science literacy, a person can gain new knowledge, explain scientific events, and draw conclusions based on facts to understand the characteristics of science and a person's willingness to be actively involved and care about science-related issues” (Ydesen & Grek, 2020).

Indonesia is a country with low literacy scores. According to the OECD, the average science score for good science literacy is 500, while Indonesia has only reached a score of 389. Indonesia is currently ranked 70th out of 78 countries participating in the PISA study (PISA, 2018). Factors that cause low literacy skills of students in Indonesia are the use of teaching materials that do not follow the character of students, low interest in reading students in understanding science literacy-based problems, learning is still teacher-centered (teaching center), learning is only fixated on textbooks, and lack of problem-solving skills of students in physics learning (Suparya et al., 2022).

Integrating technology in problem-based learning positively impacts student engagement and literacy outcomes in science (Malik, 2023; Mustaji et al., 2023; Safriana et al., 2023; Setiyawati, 2023). Technology-based education enhances student learning outcomes, academic achievement, knowledge retention, critical thinking skills, engagement, motivation, and teacher-student interactions (Rahmadani & Sunarmi, 2023). Problem-based learning significantly improves students' problem-solving skills and scientific literacy, leading to higher average scores in both areas than traditional methods (Prasetyowati & Untari, 2023). Furthermore, the production of e-modules employing augmented reality for science education exhibits tremendous validity and practicality, indicating its usefulness in boosting student learning outcomes and scientific literacy. (Gusman et al., 2022). As a result, the use of technology in problem-based learning not only increases student engagement but also improves literacy, which results in scientific education. However, Kejuruan Muda Public High School 1 researchers have observed that pupils' inadequate problem-solving skills lead to low reading scores. Factors that cause low student science literacy scores are learning resources and the use of learning media that are still limited, namely, teachers only use physics textbooks available at school; in the learning process, teachers still use conventional learning models (teaching center) and lecture methods., The teacher has never applied an interactive E-module to learning, resulting in students being less interested in participating. Efforts that can be made to improve students' science literacy in understanding and solving problems on elasticity material require the development of unique and flexible learning tools, namely in the form of modules in electronic form based on problem-based learning (Kimianti & Prasetyo, 2019). Interactive electronic modules are multimedia devices in the form of combining two or more media (audio, text, graphics, images, animations, and videos) arranged through electronic media and an interaction process (reciprocal relationship / two-way communication or more) between the media and its users (students) so as to create a more pleasant learning atmosphere (Kurniawan, 2015).

The researcher's challenge was the amount of time and energy needed to create a quality and innovative interactive electronic module. Researchers must learn the technology so that the developed module can increase students' involvement in learning. This interactive electronic module must be able to be accessed by all students online, so it requires a stable internet network.

Based on the description that the researcher has given, the researcher is interested in conducting "the development of interactive electronic modules based on problem-based learning to improve science literacy on material elasticity and Hooke's law at Kejuruan Muda Public High School 1". This research aims to determine the feasibility of interactive electronic modules, the attractiveness of interactive electronic modules, and the improvement of students' science literacy. What distinguishes
this research from previous research is that researchers compile electronic modules interactively, meaning that in the module, there are learning links that students can access and videos that students can watch. The benefits of this research are that teaching materials complement school textbooks, can improve science literacy because students are actively involved in learning, and present more creative and innovative material.

**RESEARCH METHODS**

**Research Approach**
This research uses the Research and Development (R&D) research and development model, which is a process or method used to develop and produce certain products (Sugiyono, 2020). This study uses a development research model or Research and Development (R&D). The research flow used is the ADDIE flow (analysis, design, development, implementation, evaluation) developed by (Branch, 2009).

![ADDIE research flow](image)

**Research Participants**
This research used purposive sampling, namely a sampling technique with certain considerations. Kejuruan Muda Public High School 1 has 10 classes in 11th-grade. In this research, the test subjects were 11th-grade Science 4 students. This class was chosen because it has low scientific knowledge based on the results of interviews with the physics teacher. 11th grade Science 4 has 31 students, consisting of 8 boys and 23 girls. Kejuruan Muda Public High School 1 was chosen as a trial location because, based on observations that have been made, this school has several advantages needed to implement PBL-based interactive e-modules, including easy network access to access electronic modules and complete facilities.

**Research Instruments**
This study includes essay test instruments such as pretest and posttest and non-test designs from validation sheets, interview sheets, teacher questionnaires, and student questionnaires. There are 10 scientific literacy questions contained in the E-module. The questions included are questions that have been validated with an average question validity result of 4.32 in the "very valid" category and a reliability value of 0.863 in the "very high" category (Putri, 2022).

**Data Collection**
The data collection technique in this study used a product feasibility questionnaire, an attractiveness questionnaire and a question test in the form of a pretest and posttest. Tests given to students in the form of essay questions about material elasticity and hooke's law to see the ability of science literacy. The research design used was One Group Pretest-Posttest. This means that the sample used was given a pretest to determine the initial state of students' science literacy before being treated and given a
posttest to determine the final state of students' science literacy after being treated. The sample was taken with purposive sampling technique, meaning that the sample was chosen because there were certain considerations (Sugiyono 2020).

![Figure 2. One group pretest-posttest](image)

The test applied in this research and development is a written test in essay format. The tests used are as follows. The initial test (pretest) is carried out before students use the E-module, which functions to determine the initial scientific literacy abilities that students have before using the E-module that has been developed. Final test (posttest) is an action taken after learning using a PBL-based interactive electronic module that determines the results of increasing students’ scientific literacy.

**Data Analysis**

The data analysis techniques used are as follows:

1. **Qualitative data analysis**
   
   Data analysis is done by classifying information from qualitative data in the form of input, suggestions, and criticisms in the questionnaire. This qualitative descriptive data analysis technique is used to process data from the review of media, material, and practical test experts in the form of suggestions and comments regarding product improvements for electronic physics learning modules based on a scientific approach to straight-motion material.

2. **Quantitative Data Analysis**

   Quantitative analysis is an analysis obtained from validation conducted by lecturers or experts and teacher and learner response questionnaires in the form of scores on the products developed, namely E-modules based on problem-based learning with a Likert assessment criteria scale.

**RESULTS AND DISCUSSION**

**Results**

1. **Analysis Stage (Analysis)**

   The analysis stage in this research was carried out by conducting observations at Public Senior High School 1 Kejuruan Muda. The results of observations obtained by researchers regarding the use of modules, show that Kejuruan Muda Public High School 1 has never learned to use interactive electronic modules, only using printed books provided by the school or the government. The curriculum applied at Kejuruan Muda Public High School 1 Muda is the independent curriculum. In its implementation, teachers are still confused about implementing the independent curriculum in teaching and learning, causing teachers to focus on the 2013 curriculum. Students still do not understand science literacy due to a lack of learning opportunities. The material analysis is based on the Flow of Learning Objectives (ATP), which contains phase F on the elasticity of materials included in harmonic motion. Regarding the completeness of media facilities, the school has provided various supporting learning media such as computers and projectors. Still, from the results of interviews, it is known that physics teachers are less than optimal in conducting learning with the available media, and teachers more often use printed books.

2. **Design Stage (Planning)**

   Interactive Electronic Modules based on Problem-Based Learning are prepared based on the independent curriculum teaching modules.
Pendahuluan

SIFAT GEMUK UMUM

A. KETERANGAN UMUM

B. PROFIL PENGUSA PANAMA

Buku alam faedz, porto diik baran

Cuplikan Pendahuluan
3. Development Stage (Development)

a) Validation of material and media experts

Product design validation of interactive E-modules is carried out after the initial product design is complete. Product validation is carried out by 2 lecturers as material experts and media experts and then revised according to the suggestions and input of the two experts.

The results of feasibility trials conducted by experts regarding interactive electronic modules are as follows:

<table>
<thead>
<tr>
<th>Validator</th>
<th>Average</th>
<th>Percentage</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material expert</td>
<td>3.62</td>
<td>72.5</td>
<td>Worth</td>
</tr>
<tr>
<td>Media expert</td>
<td>3.82</td>
<td>76.4</td>
<td>Worth</td>
</tr>
</tbody>
</table>

Based on the table above, it is known that the results of the feasibility test by material experts received an average score of 3.62 with a percentage of 72.5% with a “Worth” category, while the results of the feasibility test by media experts received an average score of 3.82 with a percentage of 76.4% with a “Worth” category.
4. Implementation

After the developed product is revised and declared suitable for use by the validator, the interactive E-module based on Problem-Based Learning to improve science literacy at Kejuruan Muda Public High School 1 can be used in the learning process at school.

The response results were conducted to see the attractiveness of the electronic modules that have been developed. The response results are as follows:

<table>
<thead>
<tr>
<th>Response</th>
<th>Percentage%</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>86.4</td>
<td>Very Good</td>
</tr>
<tr>
<td>Students</td>
<td>86.3</td>
<td>Very Good</td>
</tr>
</tbody>
</table>

Based on the table above, it is known that the results of the teacher's response received a percentage of 86.4% in the Very Good category, while the results of student responses received a percentage of 86.3% in the Very Good category.

The results of the increase in students' science literacy scores on material elasticity and Hooke's law were obtained from the results of the pretest and posttest questions in 11th grade Science 4. The acquisition of pretest and posttest scores shows that the learning process through interactive electronic modules based on problem-based learning on material elasticity and Hooke's law can improve students' science literacy. The N-gain test for class 11th grade Science 4 is as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>Pretest</th>
<th>Posttest</th>
<th>N-gain</th>
<th>Percentage</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>11th grade Science 4</td>
<td>37,35</td>
<td>81,52</td>
<td>0,70</td>
<td>70%</td>
<td>High</td>
</tr>
</tbody>
</table>

Based on the N-gain score test calculation test, the average value of the N-gain score of 11th grade Science 4 is 0.7, including in the high category. This shows that there is an increase in students' science literacy after learning by using interactive electronic modules.

5. Evaluation

The evaluation stage is the last stage of this research. The evaluation stage is carried out at each stage of development that researchers do. The evaluation stage is carried out to obtain product results that are appropriate and useful in learning. Through this stage, an interactive electronic module is obtained on the material of elasticity of materials and Hooke's law that suits the needs of students.

Discussion

This research and development process uses the ADDIE research model. The initial stage is analysis, and the process carried out at the analysis stage is conducting observations and interviews directly with teachers at Kejuruan Muda Public High School 1. At this stage the researcher analyzes various problems that occur in schools to obtain problem analysis, namely, curriculum analysis, student analysis, material analysis, and media analysis. Through this analysis, researchers developed media in the form of interesting and practical E-modules.

The design stage is the initial stage for researchers to start compiling the E-module that will be developed. The module design is prepared based on the results of curriculum analysis and adapted to the school curriculum. The e-module design uses Canva software to make the resulting module more attractive. Through the Canva application, researchers are able to add animations, videos, and various learning links for students to access. The e-module design starts with the cover, contents, and conclusion. The content designed in the E-module must follow the PBL learning syntax.

During the development stage, the researchers not only designed the module's color, writing, and electronic background but also created a module based on a problem-based learning method, also known as a problem-based learning method. This problem-based development is thought to be very...
exciting for students’ learning interests because students would feel challenged before they understand
the notion of learning and the concept of the learning material will be easy to understand (Ngadimin et al., 2021). Development Stage
At this stage, the researcher validates the product through experts, namely Malikussaleh University lecturers. The results of material expert validation carried out by experts obtained results with the "Feasible" criteria to be used, and the validation results of media experts obtained results with the "Feasible" criteria to be used. This is consistent with previous research (Kimianti & Prasetyo, 2019), which found validation results from material experts with "very good" criteria and media experts with "good" criteria. This is also consistent with previous research (Fitriyawany et al., 2023), which included validation results from material experts and media professionals in the category "Deserves the title of very good". When doing validation, researchers receive suggestions and feedback about the product to be used. The researchers then used the recommendations and feedback as revisions to improve the E-module to make it suitable for use in learning.

Implementation stage, before the product was tested on students, researchers conducted a pretest to see students’ initial literacy skills before learning with the E-module. Based on the results of pretest data that was carried out on 11th-grade Science 4 students, the results of scientific literacy were low. This shows that students do not understand the material and have difficulty answering questions based on scientific literacy. After carrying out the pretest test, the researcher learned with electronic modules in 11th grade Science 4. The electronic modules were designed according to the Problem-Based Learning learning model. The PBL learning model has 5 stages, this is in line with research (Kantiyah, 2022) which states that the PBL model has 5 stages, namely 1). Problem orientation, 2). Organizing, 3). Guiding individual/group experiences, 4). Develop and present the results of the work, 5). Analyze.

The increase in students' scientific literacy can be seen after students carry out learning with interactive electronic modules, there is a high increase, this is proven by the results of the posttest scores which have increased. The increase occurred because students had acquired and understood concepts through PBL-based interactive electronic modules containing examples of scientific literacy questions, so their scores increased when they did the posttest. This is proven by the average N-gain score obtained through pretest and posttest data in 11th grade Science 4 which obtained the "High" criteria. This is consistent with studies undertaken by (Nenchi et al., 2021), who got an N-gain of 0.79 in the very effective group. Then, to assess students’ interest in electronic modules during the learning process, they completed a response questionnaire, which yielded results with the criteria "Very Good”. Researchers also gave teachers questionnaires to assess the attractiveness of electronic modules in learning. The results of the teacher response questionnaire were used to see the attractiveness of the electronic module, and the result was "Very Appropriate” for use in the learning process. This is consistent with study (Mustaji et al., 2023), which found student response rates of 86% and teacher response rates of 85.8%, indicating that the final module was quite intriguing.

What distinguishes this research from earlier studies is that the researcher created a more interactive electronic module, which included learning-related films and animations to keep students engaged. This electronic module also contains links that students can access directly. Researchers discovered additional benefits, including easy student access to electronic modules due to the school's strategic location in the heart of the city, making it easy to network and use electronic modules because the school does not restrict the use of personal gadgets within the school environment.

Implementing PBL involves engaging students in critical thinking, problem-solving, and real-life applications of scientific concepts. Studies show that PBL significantly improves scientific literacy indicators such as knowledge, competency, attitude, and overall scientific literacy skills (Biruni et al., 2023; Hidayanti & Wulandari, 2023; Pakpahan, 2022; Smith et al., 2023). By integrating PBL into the curriculum, students enhance their understanding of scientific concepts and develop essential skills like critical thinking and problem-solving. PBL encourages students to think critically, discuss problems, and find solutions, thereby fostering a deeper understanding of scientific concepts and improving scientific literacy (Haji et al., 2015; Safriana et al., 2023). Overall, applying PBL in science education proves to be a valuable tool for enhancing students' scientific literacy skills and preparing them for the challenges of the 21st century.
Electronic modules developed through problem-based learning have effectively promoted science literacy among high school students. Studies have demonstrated that e-modules focusing on various topics such as coordination systems (Pertiwi, 2023), work and energy (Lazuardi et al., 2023), physics concepts (Karnando et al., 2023), and electrolyte solutions (Sujanem, 2023) have significantly improved students' analytical skills, curiosity, and science literacy. The use of the ADDIE model in developing these e-modules has ensured their validity, practicality, and high effectiveness in enhancing student learning outcomes. Additionally, the blended problem-based learning approach has further contributed to the success of these electronic modules in improving students' Critical Thinking Skills (CTS) and overall understanding of scientific concepts (Andromeda, 2023). Overall, electronic modules integrated with problem-based learning strategies have proven to be valuable tools in enhancing science literacy among high school students.

This research has been planned as well as possible, and the treatment has been carefully observed. However, some parts of this research did not go according to plan. During the study, the researchers encountered several obstacles or problems in the field. The obstacles researchers found during the research were that some students did not bring gadgets, so they had to look at their friends, making students less focused on learning. Apart from these obstacles, the researcher experienced no other obstacles, and everything went smoothly. Based on the researcher’s observations, students were also very enthusiastic about learning using interactive electronic modules.

The Evaluation Stage is the final stage of this research. The evaluation stage is carried out at each stage of development carried out by researchers. The evaluation stage is carried out to obtain product results that are appropriate and useful in learning. So, through this stage, an interactive electronic module can be obtained on material elasticity of materials and Hooke's law that suits the needs of students.

CONCLUSION
Based on expert validation of problem-based interactive electronic modules, material expert validation results were obtained in the "Feasible" category, and media expert validation results were obtained in the "Feasible" category. category which means the product developed by the researcher is suitable for use. The attractiveness of the Interactive E-module based on Problem-Based Learning was obtained from teacher responses from students who obtained "Very Good" results and from questionnaire responses from students who obtained "Very Good" results. The improvement in students' scientific literacy skills was obtained from the results of the N-Gain test for 11th grade Science 4 as a learning medium, which obtained an N-gain score of 0.70 with a percentage of 70% for the "High" criteria. In this development, researchers developed an interactive electronic module. In this electronic module, students can access links and videos. The drawback that researchers found was that the module had to be accessed using a stable network, and the development of the module used the paid Canva application, so it took a long time for researchers to develop it. Researchers suggest that further development of teaching modules can be done offline and using free development applications.

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