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Improving Problem Solving Ability Through Problem Based Learning E-Modules

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Abstract: This study aims to produce research instruments that are suitable for use in learning physics using the PBL learning model and to find out the increase in students' problem-solving abilities. The subjects of this study were 70 grade 10 students. This research was a Research and Development (R&D) study using a 4D development model consisting of Define, Design, Development, and Disseminate. The types of research data are qualitative and quantitative. collecting research data using observation and tests of students' problem-solving abilities given before and after learning. The results showed that the research instruments developed were valid for use in physics learning as evidenced by the results of the validity and reliability and the improvement of students' problem-solving skills in the modeling and implementation classes included in the medium category.

Keywords: E-Modul; Problem Based Learning; Problem Solving.

Introduction

Developments in science and technology lead to fundamental changes in education systems throughout the world, including Indonesia, to produce generations that are able to compete in overcoming the complexities of future life (Davis, 2013; Suryanti et al., 2018; Zulmaulida et al., 2018).

Educators can apply 21st Century learning in science (especially physics). The 21st century learning system is a learning transition phase, in which the currently developing curriculum leads schools to change teacher-centered learning approaches to student-centered learning (Keiler, 2018; Suharto, 2022). It aims to provide students with thinking and learning skills in the 21st century. One of the skills needed in the 21st century is problem solving (Adeoye & Jimoh, 2023; Hosnan, 2014). Problem solving skills are one of the learning objectives in terms of curriculum aspects (Sari et al., 2021).

Problem solving ability is a series of thinking processes to find the right way to get a solution to a problem (Widiasih et al., 2018). The problem solving indicator used is the indicator according to Polya (Polya, 1973; Rott, 2020; Winarti et al., 2017) presented in Table 1.

The ability to solve problems is needed by students in learning physics (Susanti et al., 2021). This is because problem solving activities can help students construct new knowledge and facilitate learning (Mukhopadhyay, 2013). Facing the challenges of the 21st century, teachers should prepare their students to become investigators, problem solvers, think critically and creatively. However, when learning physics in class tends to emphasize mastery of concepts and overrides the ability to solve students' physics problems (Aji & Hudha, 2016). Facing the challenges of the 21st century, teachers should prepare their students to become investigators, problem solvers, think critically and creatively. However, when learning physics in class tends to emphasize mastery of concepts and overrides the ability to solve students' physics problems (Aji & Hudha, 2016). Based on these facts, there must be synergy between strategies and learning models to achieve goals.

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Innovation is needed in the physics learning process which must be carried out, one of which is by applying Problem Based Learning.

Table 1. Steps and Indicators of Polya Problem Solving

Polya's Steps	Problem Solving Ability Indicator
Understand the problem	Students determine what is known in the problem and what is asked
Plan a settlement	Identify appropriate problem-solving strategies to solve the problem
Solving problems according to plan	Carry out problem solving according to what has been planned
Check again	Check whether the results obtained are in accordance with the provisions and there are no contradictions with those stated.

Physics subjects that require problem solving abilities are momentum and impulse. The results of a preliminary study conducted at class X SMA Negeri 1 Depok showed that students had difficulty understanding and solving questions related to the subject of momentum and impulse. This is because when working on physics questions given by the teacher, students more often use mathematical equations directly without doing analysis, guess the formulas used, and memorize examples of problems that have been done to work on other problems.

Implementation of the 2013 Curriculum encourages and challenges physics teachers to be creative in facilitating students to understand physics theories and concepts and be able to apply them in problem solving. The appropriate learning model to overcome these problems is the problem-based learning (PBL) model (Muskitta & Djukri, 2016; Santyasa et al., 2019). Problem Based Learning (PBL) is a learning model that trains students to work on authentic, student-centered problems (Aji & Hudha, 2016; Haji, Safriana, & Safitri, 2015) with a view to building their own knowledge, developing the ability to think and solve problems, and develop independence and self-confidence. In PBL students are required to solve problems presented by digging up as much information as possible, then analyzing it, and finding solutions. Malan et al. (2014), states that the implementation of learning using the PBL learning model can develop students' thinking skills through information processing, critical thinking, and instilling in students to be responsible.

Good teaching materials are audio-visual teaching materials that can accelerate understanding, improve student memory, foster student interest and most importantly can provide a relationship between subject matter and the real world, so that students can see, feel, and have a real picture not in a real world. just imagination (Sumiati & Tirtayani, 2021). Electronic modules (e-modules) are a good development choice, because conventional ones (printed modules) are less interactive and have static pictures or monotonous displays. While e-modules can interactively present material displayed by multimedia such as videos, animations, simulations, and questions with direct feedback (Irwansyah et al., 2017).

The reason for choosing the e-module is because it refers to the syntax of the problem-based learning model so that the phases in the e-module facilitate indicators of problem solving. Based on this description, the effectiveness of learning Physics can be an alternative to improve students' problem-solving abilities. Therefore, this article will discuss about Improving Problem Solving Ability Through Problem Based Learning E-modules.

Method

The subjects used were class X MIPA 3 consists of 35 students that becomes modeling class and 35 students in class X MIPA 1 that becomes the implementation class.The research method used is the Research and Development (R&D) research method. (Sugiyono, 2015) states that the R&D research method is the method used to produce products and test the feasibility of these products. Therefore, a research design that is consistent with this study adapts the 4D model which consists of four stages, namely the Define, Design, Develop, and Disseminate stages (Thiagarajan & Semmel, 1974). Research flow can be seen in the Figure 1.

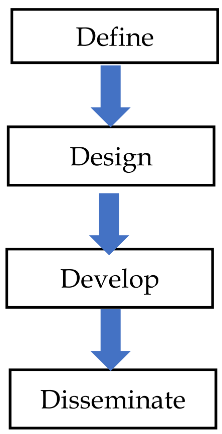

Figure 1. Research Design

Define Stage

Preliminary Analysis: The observation results stated that the learning method used was lecture. It's rare for teachers to deliver material using technology. In addition, the problem-solving aspect is given less attention, more attention is given to students' cognitive learning outcomes.

Student Analysis: The results of the student analysis showed that the students in class X SMAN 1 Depok Sleman were on average 15-16 years old. The characteristics of their cognitive development are at the formal operational stage which has many creative and innovative ideas. In addition, students begin to be able to think logically about abstract ideas, can distinguish the concrete from the abstract, and they evaluate what they have learned.

Curriculum Analysis: The results of the curriculum analysis produced several Competency Achievement Indicators (GPA) and learning objectives that are in accordance with the momentum and impulse material. Competency Achievement Indicators can be seen in Table 2.

Table 2. Indicators of Competence Achievement

Indicators of Competence Achievement	
3.10.1	analyze the concept of momentum and impulse
3.10.2	analyze the relationship of momentum and impulse
3.10.3	formulate the concepts of momentum and impulse
4.10.1	presents the results of investigations of momentum and impulse in everyday life

Concept Analysis: The results of the concept analysis are revealed by making a concept map of momentum and impulse material according to the physics material used in learning.

Design Stage

Preparation of Research Instruments; The research instrument preparation stage was carried out by compiling instruments to measure students' problem-solving abilities. The measurement instrument used to measure students' problem-solving abilities consisted of 5 essay questions. Determination of Learning Devices; The learning tools used include the Learning Implementation Plan (RPP) for the first meeting for 2 Hours of Learning.

Selection of Learning Media; The learning media chosen in this study is e-module. The e-module was chosen because the learning media can explain events related to Momentum and Impulse material in everyday life practically and is able to foster independence in students, so they are able to solve problems. Preliminary Design: The initial design stage consists of the steps taken in developing a Problem Based Learning-based e-module. The steps taken are e-book design.

Develop Stage

The initial design stage consists of the steps taken in developing a Problem Based Learning-based e-module. The steps taken are e-book design.

Disseminate Stage

The dissemination stage is carried out by disseminating learning tools and research results from development to students, teachers, or schools. In addition, scientific articles from this research are also published in scientific journals so that they can be useful for researchers or readers in general.

Data analysis technique

The feasibility of the instrument was obtained from the validation scores given by two validators and analyzed using the Aiken's V equation shown by equation 1.

$$V = \frac{\sum s}{n(c-1)} \tag{1}$$

With V is the content validity coefficient, s is $r - l_0$, r is given by the validator, l_0 is the lowest validity rating score, c is the highest validity rating score, dan n is the number of respondents. The Aiken's V index category is divided into three categories as shown in Table 3.

Tabel 3. Aiken'V Validity Criteria

Validity Range	Category
$0.8 < V \leq 1$	Very good
$0.6 < V \leq 0.8$	Good
$0.4 < V \leq 0.6$	Enough
$0.2 < V \leq 0.4$	Not enough

The next step is to analyze the test instrument reliability scores that have been done by students. This analysis is obtained using the Alpha Cronbach equation. This method is carried out by assessing the results of student test questions by two expert validations and then testing the level of agreement using Cronbach's Alpha which is shown by the equation 2. r_{11} is the reliability of the instrument, k is the number of items, ${\sigma_b}^2$ is the total variance of the items and ${\sigma_t}^2$ is the total variance.

$$r_{11} = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum {\sigma_b}^2}{{\sigma_t}^2}\right) \tag{2}$$

Meanwhile, the increase in problem solving ability can be seen through the results of working on the pretest and posttest questions which are analyzed using the standard gain equation. This technique is done by calculating the gain value first (Hake, 2012). The standard gain equation used is shown by the following equation 3.

$$std\ gain < g >= \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score} \tag{3}$$

g is the standard gain, the posttest and pretest scores are the posttest and pretest scores obtained by students, and the maximum score is the probability that students get the greatest score. While the interpretation of the standard gain is shown in Table 4.

Table 4. N-Gain Value Category

N-Gain Value	Criteria
$g > 0.7$	High
$0.3 < g < 0.7$	Medium
$g < 0.3$	Low

Result and Discussion

In connection with the first research objective, the feasibility of the research instrument was obtained through the validation results of the expert validator. The expert validator who validates the developed instrument is a colleague. The results of the validity of learning devices are shown in Table 5.

Table 5. Learning Instrument Validation Results

Learning Instruments	Validity	Category
RPP	0.81	Very good
E-module	0.83	Very good
Average	0.82	Very good

Based on Table 5, all the learning tools developed have very good or valid categories, but the learning tools that have the lowest validity score are lesson plans (V = 0.81). Meanwhile, the results of the validity of the research instrument to measure the increase in students' problem-solving abilities in the form of a test are shown in Table 6. There are four aspects of validity that are assessed from the test instrument to measure the increase in problem-solving abilities, namely aspects of conformity with indicators, instrument completeness, construction, suitability content and language. The results of the instrument validity test for students' problem-solving abilities can be seen in Table 6.

Tabel 6. The results of the validity of the problem-solving ability instrument

Assessment Aspects	(V)	Category
Compatibility with indicators	0.67	Good
Instrument equipment	0.67	Good
Construction	1.00	Very Good
Content suitability	0.67	Good
Language	1.00	Very Good
Average	0.80	Good

The results of the instrument validity test for students' problem-solving abilities show that two aspects of the research instrument have a validity score at intervals of 0.80 which is included in the very good category, but the aspects of conformity with indicators, instrument completeness, and content suitability in the questions have the lowest validity score of 0. 67 with good category. It is possible that the developed test instrument has low momentum and impulse material quality.

Thus, it can be stated that the E-Module learning device assisted by the PBL model which consists of lesson plans and E-Module is valid and suitable for use in class X MIPA physics learning at SMAN 1 Depok which consists of a modeling class and an implementation class. So that the learning device can be used in all X MIPA classes whose student characteristics and other characteristics are like the characteristics of X MIPA class students at SMAN 1 Depok. This is in accordance with the view (Hasibuan et al., 2018) which states that a learning device that is developed and meets predetermined eligibility standards, then the learning device can be used in special physics learning activities in all high schools with homogeneous characteristics and the possibility of learning objectives can be achieved properly.

However, the validity value of this learning device is close to the lowest value, very good. Many factors influence this, which can be influenced by a decrease in the number of validators as well as random validator reviews assessing a range of ratings from lowest to highest. The results of random validation from the lowest to the highest ranking range are characteristics of learning devices or devices that are valid or appropriate for use in research (Huang & Chiu, 2015).

In addition to considering the results of validity, the test instrument to measure the increase in students' problem-solving skills also considers the reliability results obtained from the results of student test questions and is tested using the Cronbach alpha equation shown in Table 7.

Table 7. Problem Solving Instrument Reliability Results

Class		r_{11}	Category
Modeling	*Pretest*	0.84	Reliable
	Posttest	0.89	Reliable
Implementation	*Pretest*	0.86	Reliable
	Posttest	0.91	Reliable

Based on the assessment of the results of the test questions in the modeling and implementation class, it shows that in general the research instruments developed are reliable. These results indicate that the research instrument in the form of a test instrument can be used to measure the increase in students' problem-solving abilities at school. (Ku, 2009) states that the instrument is suitable for use in research if the instrument is valid and reliable.

Based on Table 7 it can be seen that the results of the reliability of the problem-solving instrument for the modeling class and the implementation class at SMAN 1

Depok obtained different reliability results. In this case the level of reliability for the implementation class obtained higher reliability results than the reliability of the modeling class. This often happens because each assessor gives an assessment of each research instrument that has different views, there are times when the first assessor gives the highest score on a certain number of items, but other assessors give the lowest score on that number of items (Yuliani & Suragih, 2015).

The results of the pretest and posttest of students' problem-solving abilities in the modeling class at SMAN 1 Depok can be observed in Figure 2. Figure 2 shows the difference between the results of the pretest and posttest for aspects of understanding the problem, planning problem solving, solving problems, and checking again in the modeling class. Improved aspects of understanding problems with an average of 6.43, aspects of planning a settlement with an average of 5.71, aspects of solving problems with an average of 6.12 and aspects of re-checking with an average of 5.74, so an increase in students' problem-solving abilities in the modeling class with an average of 24.00 is obtained from the sum of the increases in the four indicators.

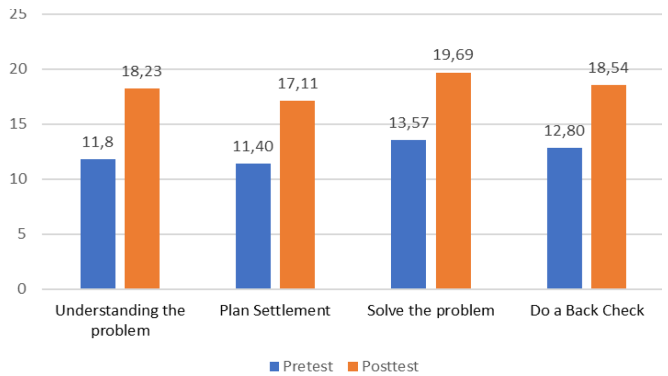

Figure 2. Improved modeling class problem solving skills.

The results of the pretest and posttest of students' problem-solving abilities in the implementation class at SMAN 1 Depok can be observed in Figure 3.

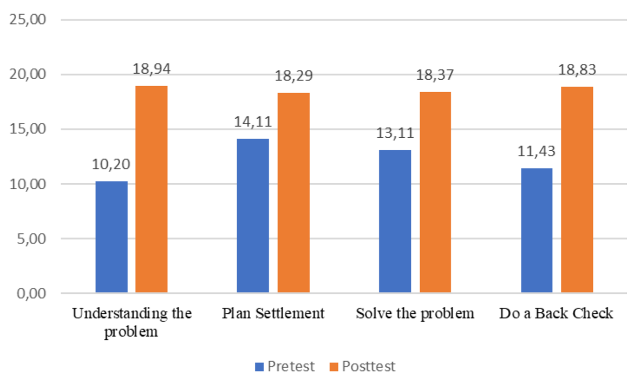

Figure 3. Improved implementation class problem solving abilities.

Figure 3 shows the difference between the results of the pretest and posttest for aspects of understanding the problem, planning problem solving, solving problems, and checking again in the implementation class. Improved aspects of understanding problems with an average of 8.74, aspects of planning a settlement with an average of 4.18, aspects of solving problems with an average of 5.26 and re-checking aspects with an average of 7.40, so an increase in students' problem-solving abilities in the implementation class with an average of 25.58 was obtained from the sum of the increases in the four indicators.

In the modeling and implementation class, the problem-solving planning indicator has the lowest average compared to other problem-solving ability indicators. This shows that the weak point of students' problem solving abilities lies in the problem planning process which is also in accordance with the research conducted by (Yanti et al., 2016). The low success rate of this indicator is caused by several factors. First, based on the results of the interviews, students stated that they were rarely trained in problem solving skills in learning and questions in the form of long texts made students less thorough, so that problem planning was made less than optimal. In addition, the factor of students' haste in planning problem-solving problems is also the cause of the less-than-optimal implementation of problem-solving. This needs attention, because solving problems with the problem solving stage requires quite a long time in the process, and cannot be done in a hurry. (Maemunah et al., 2019).

Furthermore, the increase in problem-solving abilities for each indicator in the modeling and implementation class can be seen through the results of the pretest and posttest questions which are analyzed using the standard gain equation for each indicator (Hake, 2012). The N-gain results can be seen in Table 8 and Table 9.

Table 10. Modeling Class N-gain Score

Indicator of problem-solving ability	N-gain	Category
Understanding the problem	0.48	currently
Plan Settlement	0.39	currently
Solve the problem	0.42	currently
Do a Back Check	0.44	currently
Average	0.43	currently

Table 9. Implementation Class N-gain Score

Indicator of problem-solving ability	N-gain	Category
Understanding the problem	0.58	currently
Plan Settlement	0.32	currently
Solve the problem	0.40	currently
Do a Back Check	0.52	currently
Average	0.45	currently

The results of the table above show that the lowest change is in the problem-solving planning indicator, however, the increase in change is still in the moderate category. Where this change still allows for an increase. So that the average value of N-gain in the modeling and implementation class is 0.43 and 0.45.

Based on the explanation above, because it was tested in two classes with different teachers, different improvement results can occur because students from the two classes generally rarely take part in learning using the PBL model, but mostly use the lecture model. Students certainly need a longer adaptation in learning by using the PBL model so that learning objectives can be achieved optimally. (Wartono et al., 2018) stated that the advantage of the PBL model compared to lectures was being able to cultivate high order thinking skills, one of which was solving problems in everyday life scientifically. In addition, N-gain was obtained with the same category so that it can be concluded that problem-based learning-based e-modules are able to improve students' problem-solving abilities. (Asyhari & Sifa'i, 2021; Yuberti et al., 2019) states that problem-based learning is effective in increasing problem-solving skills.

Conclusion

Based on the results and discussion, it was concluded that the research instrument developed was suitable for learning using the PBL learning model to improve students' problem-solving abilities. ability as evidenced by the results of validity and reliability. While the increase in students' problem-solving abilities in the modeling and implementation classes were respectively 24.00 and 25.58 with standard gain values of 0.43 and 0.45 which were included in the medium category.

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Author Contribution

In this study, the author makes a different contribution. Theory analysis, data collection, analysis, and paper writing were carried out by author 1, while the supervision and review of writing was carried out by author 2.

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Conflicts of Interests

The authors declare no conflict of interest.

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