JISE 13 (1) (2024): 29-36

Journal of Innovative Science Education

https://journal.unnes.ac.id/journals/jise/

The Analysis of Phase E Students' Problem-Solving Skills on Global Warming Materials with the Help of the Problem-Based Electronic Module

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Article Info

Article History :
October 2023
Accepted
December 2023
Published
April 2024

Keywords:
Problem-Solving; Global Warming; Problem-Based Electronic Module

Abstract

Problem-solving is one of the most essential skills in 21st-century learning which prepares students to face the increasingly complex problems of human life. The phenomenon of global warming remains a big problem that the world is facing. For this reason, students are expected to be able to practice their problem-solving skills in analyzing global warming issues through learning physics. This research aims to determine the extent of students' problem-solving skills related to the global warming phenomenon. The research used a descriptive method with a quantitative approach. This one-shot case study involved 22 phase E students of SMAS Katolik St. Gabriel Maumere. The data collection instrument included 8 question items containing four indicators of problem-solving abilities on global warming. Previously, students had to learn about the topic with the help of a problem-based electronic module. The results showed that the highest level of problem-solving skills was the indicator of implementing strategies with 87%, and the lowest percentage was in the evaluation category with 64%. The overall score of problem-solving skills was 72.25% in the high category, meaning that the application of the problem-based e-module provides positive results for students to transfer their knowledge in analyzing problems that occur in real life.

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p-ISSN 2252-6412
e-ISSN 2502-4523

INTRODUCTION

The 21st-century learning is a transition in which the developed curriculum requires schools to change their teacher-centered approach to a student-centered one. In the 21st-century, teachers must create exciting learning and have excellent class management to stimulate students' liveliness (Prastyo et al., 2024). The Ministry of Education, Culture, Research and Technology (Kemendikbudristek) officially launched a new curriculum called the Merdeka ("Independent") Curriculum, which focuses on developing students' character and competencies and the freedom to choose their learning interests (Utari & Muadin, 2023). This Curriculum supports creativity and innovation from teachers and students, hoping that both parties contribute to improving learning quality (Mairizwan et al., 2022). Apart from that, this Curriculum also emphasizes many student competency developments, including problem-solving skills.

Physics learning sharpens students' skills through various physics problems found in everyday life. In solving problems, especially physics, a student cannot just rely on memorization but needs to be supported by other competencies (Mustofa & Rusdiana, 2016). The skills in question are understanding problems, formulating solutions, implementing solutions, and evaluation (Sari et al., 2023). Understanding the discussed problem is an initial step that students must go through to formulate a strategy or find a solution, implement a planned solution or strategy, and carry out a final and evaluated solution (Sapriyadin et al., 2023). Students who have fulfilled these four aspects are said to master problem-solving abilities. Physics studies many natural phenomena around us (Suban et al., 2023). These complex phenomena cannot be separated from the physics rules that bind them. For this reason, students must be able to solve a problem based on the related physics solutions (Reddy & Panacharoensawad, 2017).

Getting used to seeking solutions to each problem is beneficial for students' future. However, this contradicts the facts found at SMAS Katolik St. Gabriel Maumere. Students needed help understanding physics problems, both contextual problems and calculations (Riskyanti et al., 2021). This is a common issue found in subjects needing much computing (Zhu et al., 2023). In the Merdeka Curriculum, Phase E is often known as the class X of Senior High School. Students who fall into this phase have just completed their studies at the junior high school level. These early graders need deeper conceptual understanding and stimulation to grow creativity, which could be achieved through problem-based learning modules.

One of the physics materials whose contextual problems are often encountered in everyday life is the global warming topic, a worldwide impactful issue ranging from increasing temperatures, climate change, and unpredictable weather (Camelia et al., 2023). In response to this situation, a teacher needs to innovate in improving the quality of learning and training students to solve problems from the simplest materials. This can happen when combined with the appropriate models and methods (Trianawati et al., 2023), one of which is the problem-based learning model (Trianawati et al., 2023; Ince, 2018). This innovative learning model provides an active learning atmosphere where students are involved in solving a problem through the scientific method stages (Trianawati et al., 2023). As students are allowed to learn knowledge related to everyday life problems, they simultaneously have time to hone their problem-solving skills (Putri & Junaedi, 2022) and improve their critical thinking (Suryaningtyas et al., 2020). Interview results at SMAS Katolik St. Gabriel Maumere showed that teachers were not used to implementing the PBL-based learning model but, instead, the conventional lecture method, leading to boredom and disinterest in studying physics. Another alternative offered was the use of electronic-based teaching materials. E-modules contain text, images, animations, and videos via electronic devices, computers, or smartphones (Wulandari & Jumadi, 2023). One of the critical advantages of e-modules is their efficiency in delivering lessons and their accessibility with the click of a button to retrieve anywhere and at any time (Azmi et al., 2023; Asih et al., 2022). Suryaningtyas et al. (2020) indicated that learning with a PBL-e-module can yield more effective and adaptable learning outcomes. Other research indicated that learning with modules has enhanced problem-solving skills in aspiring physics subjects (Malik et al., 2023). Similarly, Syafii & Yasin (2013) found that PBL-based e-module learning can improve problem-solving skills, student achievement, and

student learning outcomes. This research aims to analyze the extent to which students can solve problems surrounding the global warming phenomena. It is pivotal because schools shall instill the upcoming generation's responsibility for the survival of all creatures on earth.

METHODS

This is a descriptive study with a quantitative approach. The method is a one-shot case study, which is expected to thoroughly analyze students' problem-solving skills by data support. The research subject included 22 students in class X-E-3 of SMAS Katolik St. Gabriel Maumere, East Nusa Tenggara (NTT). The instrument for collecting data consisted of 8 test items on global warming materials. The score was given based on the steps in solving the questions. The tested question items were validated by two experts using the V Aiken equation (Suban et al., 2021) as follows.

$$v = \frac{\sum s}{[n(c-1)]}$$

Information:

s = $r - l_o$
r = The score given by the validator
l_o = Lowest validity assessment score
n = Number of validators
c = Highest validity assessment score

The validity results from the two experts were then interpreted on the Aiken V index scale. If the V Aiken index is in the score range of 0.4-0.8, then the instrument is in the medium category. If the V Aiken index is less than 0.4, then the instrument is in the low category, and if the V Aiken index is more than 0.8, then the instrument is in the high category (Suban et al., 2021). Question item criteria are adjusted to the four indicators of problem-solving skills, as seen in Table 1.

Table 1. Indicators of Problem-Solving Skills

Indicator	Test Items
Understanding the problem	1.2
Formulating solutions	3.4
Implementing the solutions	5.6
Evaluation	7.8

The following equation was used to calculate each aspect's problem-solving skills percentage.

$$P_x = \frac{R_x}{nS_x} 100\%$$

Information:

P_x : Aspect Percentage x
R_x : Aspect of total score x
n : Number of respondents
S_x : Maximum score

The calculation results were then converted to the problem-solving criteria for each aspect as presented in Table 2 (Mustafa & Rusdiana, 2016).

Table 2. Criteria for Ability for Each Aspect of Student Problem Solving

Aspect Percentage	Category
$80 < P_x \leq 100$	Very high
$60 < P_x \leq 80$	High
$40 < P_x \leq 60$	Enough
$20 < P_x \leq 40$	Low
$P_x \leq 20$	Very Low

RESULTS AND DISCUSSION

The students' problem-solving skills were measured under four indicators. Previously, the students had learned global warming materials with the help of the Problem-Based E-Module. The learning implementation has been adapted to the Merdeka Curriculum. Figure 1 presents the display of the Problem-Based E-Module.

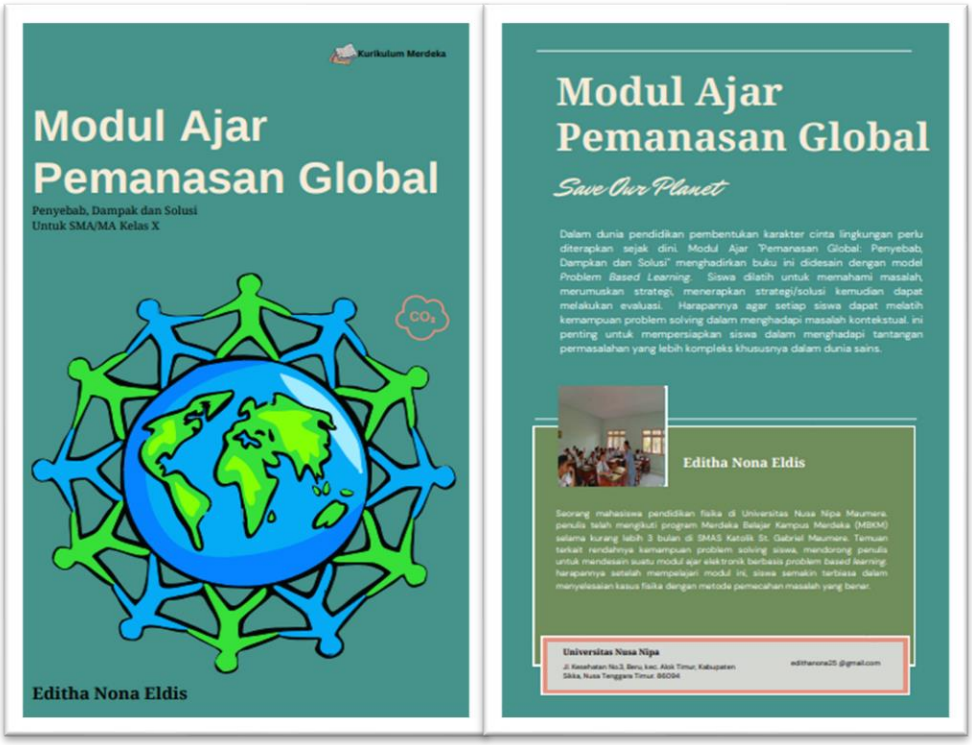

Figure 1. Display of the Problem-Based Electronic Module

A total of 8 test items were validated by two experts, whose results are presented in the following Table 3.

Table 3. Test Item Validation Results

Question Number	Aiken's V Value	Category	Information
1	1.00	High	Valid
2	0.75	Moderate	Valid
3	1.00	High	Valid
4	1.00	High	Valid
5	0.875	Moderate	Valid
6	0.625	Moderate	Valid
7	1.00	High	Valid
8	0.625	Moderate	Valid

Table 3 shows that all test items on global warming materials are valid, showing the appropriateness for use. Furthermore, the 60-minute test was given to 22 students in class X-E-3 at SMAS Katolik St. Gabriel Maumere. The results are from students' short answers, which were rated and analyzed. The analysis results of the students' problem-solving skills for each indicator are shown in Figure 2.

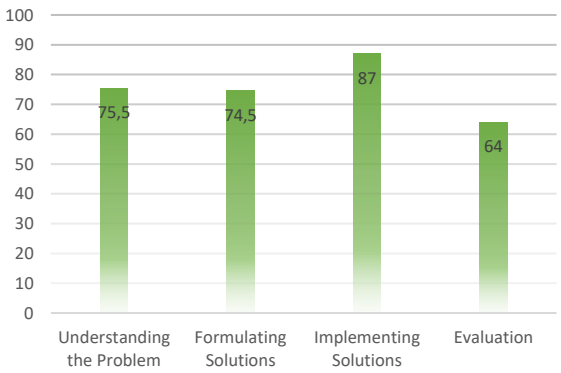

Figure 2. The Percentage Mapping of Students' Problem-Solving Skills for Each Indicator

Understanding the Problem

The test item:

"The increase in temperature we are experiencing now is one of the causes of global warming. Heatwaves cause dryness, fires, skin irritation, and many oth ers. The longer we depend on fossil fuels, the higher the greenhouse gas emissions will be, extreme heat will always lock us in. From the statement above, explain the relationship between the increasing hot temperatures and global warming."

The problem raised in the test item is related to global warming, triggered by temperature increases. On average, the students answered that heatwaves occur due to excessive gas production in the atmosphere, preventing heat from escaping. Meanwhile, the earth also receives solar radiation daily, so a high increase in temperature results in global warming. However, some students needed to understand the problem correctly. Instead, they explained the definition of heatwave without connecting the relationship between increasing hot temperatures and global warming.

Formulating Solutions

The test item:

"From January to April 2018, forest and land fires management occurred in Riau Province. Based on data from the Riau Regional Disaster Management Agency (Badan Penanggulangan Bencana Daerah), forest fires reached more than 1,000 hectares (ha) in 2018, while land fires occurred in 11 areas of 12 districts and cities including 1 ha in Rokan Hulu, 80.75 ha in Rokan Hilir, 114.25 ha in Dumai, 160.5ha in Bengkalis, 896.61 ha in Meranti Islands, 131.5 ha in Siak, 31 ha in Pekanbaru, 19.25 ha in Kampar, 60 ha in Pelalawan, 121.5 ha in Indragiri Hilir, and 31 ha in Indragiri Hulu. The fire caused smoke haze reaching the surface that many residents were affected by respiratory problems. Apart from that, it is also feared that the fire will spread to wider scale if it is not immediately managed following several fire spots nearby. How to minimize the effect of fire smoke on the residents' health? How to minimize fires in the fire-prone areas?"

The questions are to measure students' ability to develop appropriate solutions. The proposed issue is a respiratory disorder experienced by residents as a result of forest fires. The students were asked to provide appropriate strategies to minimize the influence of smoke on the residents' health. The solutions included reducing outdoor activities, using masks, consuming lots of mineral water, and protecting food and drinks from pollution. However, seven students were not able to provide the right solutions, instead, statements regarding the types of respiratory disorders. This happens due to a need for more problem understanding of the asked questions. Another question reveals the problem of forest fires caused by climate change. It explores students' abilities in formulating appropriate strategies to minimize fires, especially in areas potentially affected by climate change. Generally, the solutions include avoiding burning activities around the land, mass reforestation, and analyzing fire-prone spots. However, some students answered contradictory to the problem context and instead gave their opinions regarding mitigation efforts.

Implementing Solutions

The test item:

"The rise of global sea level is accelerating as the ice sheets in Antarctica and Greenland melt. This conclusion is drawn based on the analysis results of the first satellite data over 25 years. This research, carried out by United States scientists, has calculated the rate of global average sea level rise, which has increased at a constant rate of 3 mm per year, and has also experienced an additional rise of 0.08 mm per year, which occurs every year since 1993. The acceleration is largely driven by the melting of the Antarctic and Greenland ice sheets and is likely to accelerate in the future, scientists say. If this rate of change continues at this rate, the global average sea change will increase by 61 cm between now and 2100. These findings are reported in the journal Proceedings of the National Academy of Sciences published Tuesday (13/02/2018). What actions should be taken to minimize sea level rise?"

The question is to measure students' ability to apply appropriate actions. The proposed problem is the rise in sea levels caused by melting the ice sheet in Antarctica. The students were asked to provide their opinions regarding actions taken to minimize sea level rise. Averagely, the students answered by reducing greenhouse gas emissions. The melting of ice sheets is one of the impacts caused by global warming. The right strategy is to reduce activities that cause an increase in greenhouse emissions. However, some students could not answer correctly; instead, they stated that glaciers around Mount Everest's slopes were warming more quickly. In other words, students still need to be able to

understand the raised question and, thus, cannot apply the right solution.

Evaluation

The test item:

"From January to April 2018, forest and land fire management occurred in Riau Province. Based on data from the Riau Regional Disaster Management Agency (Badan Penanggulangan Bencana Daerah), forest fires reached more than 1,000 hectares (ha) in 2018, while land fires occurred in 11 areas of 12 districts and cities including 1 ha in Rokan Hulu, 80.75 ha in Rokan Hilir, 114.25 ha in Dumai, 160.5ha in Bengkalis, 896.61 ha in Meranti Islands, 131.5 ha in Siak, 31 ha in Pekanbaru, 19.25 ha in Kampar, 60 ha in Pelalawan, 121.5 ha in Indragiri Hilir, and 31 ha in Indragiri Hulu. The fire caused smoke haze to reach the surface, and many residents were affected by respiratory problems. It is also feared that the fire will spread to a broader scale if it is not immediately managed following several fire spots nearby. How much forest area was burned in Riau Province in 2018?

The item questions information regarding forest fires occurring in Riau Province with detailed data on the area of land that experienced fires in various regions. The students generally answered that the total land that experienced forest fires was 1000 Ha, which is false. They should have paid more attention to the questions and were influenced by the initial data in the questions stating that more than 1,000 hectares of land were burned in 2018. This statement is a generalization and does not show a definite number. The correct answer is obtained by adding up the total land affected, a detail most students missed.

Students' problem-solving abilities regarding global warming material are in the high category, in addition to using Problem-Based E-Module. This means that the global warming material is relatively easy and understandable. Students can understand problems, formulate solutions, apply strategies, and evaluate well. The outcomes align with Broseghini et al. (2024) and Mahendra et al. (2023), stating that the PBL-based basic chemistry e-module effectively improves students' problem-solving skills. The used e-module helps students understand global warming in terms of causes, consequences, and contextual solutions. This confirms Arini et al. (2019) believe that students will only understand material once they actively do something and reflect on the meaning of what they did in learning.

CONCLUSION

This research shows that the average problem-solving skills of 22 SMAS Katolik St. Gabriel Maumere students are in the high category. Implementing solutions is ranked highest, followed by understanding problems, finding solutions, and evaluating. Despite being the second best, understanding problems is a crucial skill, as good comprehension can help students in further analysis regarding appropriate strategies and evaluation. The results are a fundamental analysis regarding the students' potential, which is beneficial for teachers as a benchmark for shaping problem-solving abilities in the field of science, specifically in more complex physics problems.

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