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# The Effectiveness of Developing Science Learning Devices with the Integrated PBL Model of the STEM Approach in Improving Students' Problem-Solving Ability and Self-Efficacy

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**Abstract:** Natural science learning is a process of discovery, therefore science learning includes systematic exploration activities, which means not only mastering systematic accumulation but also the process of discovery. It's helps aid participants in solving problems. However, the phenomena encountered show that students' problem-solving abilities are still quite low. The low problem-solving ability is also influenced by students' self-efficacy. Therefore, it is necessary to innovate the development of science learning tools using appropriate models. One model that can be use is the integrated PBL model with the STEM approach. The development carried out aims to increase students' problem-solving abilities and self-efficacy. This type of research is R&D research with the ADDIE development model. Study findings indicate that students' problem-solving abilities have increased by 0.81 in the high category and their self-efficacy has increased by 0.30 in the medium category. These findings are based on the acquisition of the N-gain value. Consequently, it is beneficial to increase students' problem-solving skills and self-efficacy to design science learning resources that incorporate the PBL model and the STEM approach.

**Keywords:** PBL model; Problem solving skills; Self-efficacy; STEM approach

## Introduction

The IPA for natural science is a special type of knowledge that connects one way to another by making observations, experiments, conclusions, and theoretical preparations (Wicaksono, 2020). Furthermore Ramadanti (2020) and Muliadi et al. (2022) argues that learning science is a process of discovery, therefore learning science includes systematic exploration activities, which means not only mastering systematic accumulation but also regarding the process of discovery. In general, learning science serves the following purposes: it informs students about the different kinds of natural and artificial environments and their roles in daily life; it helps them develop the mental and physical processes needed to acquire scientific knowledge; and it gives them the insights, attitudes, and values that they need to improve their quality of life in general (Sakila et al., 2023). Referring to this definition, learning science in schools requires educators not only to convey learning material but also to facilitate want kids to be capable to discover the science concepts they are learning for themselves.

The discovery of a science concept helps students in solving a problem. Where this ability trains students' HOTS. Meanwhile, according to Laia et al. (2021), problem-solving skills are an important part of learning because this ability can train students to build a sense of confidence in solving problems and being able to improve their ability to make decisions. problem-solving skills can describe skills or potential in students so that they can solve problems and can apply them (Suryani, et al., 2020). Based on this description, generically, problem-solving skills are a basic ability to improve students' HOTS abilities. However, students' problem-solving skills also influenced by their self-efficacy.

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Self-efficacy, or self-confidence, is what influences students' motivation and accomplishment levels and can motivate them to participate in learning activities (Mukti & Tentama, 2019). In line with this statement, Akuba et al. (2020) explained that Self-efficacy is the conviction in one's own abilities or competence to complete a task and achieve a result under certain conditions. The existence of self-efficacy in students will help them in making choices and efforts to move forward, the persistence and perseverance shown in facing difficulties, as well as the degree of anxiety or the level of calm experienced when individuals maintain tasks in life (Zagoto, 2019). The self-efficacy theory postulates that learners' persistence, effort, and self-regulation—all of which contribute to more favorable learning outcomes—are influenced by their sense of self-efficacy and that this improves academic accomplishment. Afterward, the empirical study confirmed this (Nurazmi & Bancong, 2021). Therefore self-efficacy is also one of the things that need to be considered in students.

However, the reality that occurs in the field shows that there are still many students who have less qualified problem solving skills. Students' self-efficacy has an impact on this as well. Where students tend to be easily discouraged from solving difficulties in terms of solving problems. This phenomenon then has an impact on the quality of student learning outcomes. Based on these problems, educators need to be ashamed of innovation in learning. One of them is to develop science learning tools using learning models and approaches that can facilitate students' problem-solving skills and self-efficacy, namely the STEM method combined with the Problem-Based Learning (PBL) model.

The PBL approach is a way of teaching that encourages students to work on real-world issues in order to build their knowledge base, hone higher-order thinking abilities, and gain independence and confidence (Mayasari et al., 2022). PBL allows students to build their knowledge by basing their lessons on actual challenges found in the real world. wherein learners are supposed to cultivate critical thinking abilities and fundamental scientific thinking (Nurazmi & Bancong, 2021). Meanwhile, the STEM approach is an approach that can attract students to enjoy learning discussions in class and participate in solving meaningful problems (Septiani et al., 2020). Meanwhile, science education and technology are intimately intertwined, claims Ariyatun et al. (2020), people's lives can be enhanced and supported by technology. In STEM (science, technology, engineering, and mathematics) oriented learning, these prerequisites actually make integration possible. The problem-based learning (PBL) paradigm, a collection of instructional techniques that enable students to undertake research, integrate theory and practice, and apply knowledge, is another typical learning experience in STEM-focused institutions (Vistara et al., 2023). Therefore, the selection of the integrated PBL model with the STEM approach is considered suitable to facilitate students to have better problem-solving skills and self-efficacy.

The purpose of this project is to create science learning aids that combine the PBL model with the STEM approach, and to assess how well the devices work to increase students' capacity for problem-solving and self-efficacy.

## Method

In this example, science learning aids with an integrated PBL model and the STEM approach are the products of research and development (R&D), which is also utilized to test the efficacy of the goods produced (Rustandi & Rismayanti, 2021). To create new or improved models that govern the development of instructional products and resources, as well as new or improved methods for studying, developing, and evaluating processes in a methodical manner, is known as development and research (Kamal, 2020; Lase 2023).

What makes R&D research crucial? The process of identifying needs, developing products, and validating those products into new products that meet needs is known as scientific research and development in the field of education. The development of a new product adheres to specific standards of quality, efficacy, and efficiency by employing methodical approaches and field testing (Permana, 2022; Okpatrioka 2023).

While the procedure of this research is to use the development paradigm of ADDIE. The phases that make up the ADDIE development paradigm include analysis, design, development, implementation, and assessment. Where the ADDIE development model has the advantage that at each stage an evaluation is carried out and has structured steps that are more generic (Zuhro et. al., 2022). According to a different viewpoint, the ADDIE development model has the advantages of being straightforward, simple to understand, and having a methodical framework (Lailia, 2020).

The analysis technique for product effectiveness in increasing KPM and student self-efficacy is measured using N-Gain with the following classifications.

**Table 1**. Standard Gain Interpretation (Arsanty & Wiyatmo, 2017)

| Grade <g> | Classification |
|---|---|
| 0.70<g<1.00 | High |
| 0.30<g<0.70 | Medium |
| 0.0<g<0.30 | Low |

The increase in students' problem-solving abilities was measured through the results of the pretest and posttest based on the KPM test questions which consisted of 8 questions. While the instrument for measuring student self-efficacy is by using a questionnaire consisting of 30 statements based on the description of the indicators from the three dimensions used, namely magnitude, generality, and strength.

## Result and Discussion

The development and research done make reference to the ADDIE model's phases (Analysis, Design, Develop, Implementation, and Evaluation) (Syahfitri et al., 2023). At the analysis stage, a needs analysis is carried out. Where observations and interviews were carried out to find the problems of learning science more specifically at school and it was found that student's problem-solving abilities were still low, especially in vibration, wave, and sound material. The observations and interviews were conducted at one of the MTs in the Mataram city. Then an analysis of students was also carried out to review the factors causing low problem-solving abilities from the perspective of the students themselves, it was found that students did not have confidence (self-efficacy) in themselves to be able to solve problems properly. After analyzing the needs and analysis of students, then proceed with material analysis. Because based on the needs analysis, it was found that the students' problem-solving abilities were low, especially on vibration, wave, and sound material, so the researchers focused on this material. Where this material coincides with Basic Competency (KD) 3.10 and 4.10. Following a description of the competency achievement indicators (GPA) and the creation of learning objectives, a material analysis was conducted to determine the breadth and depth of the content.

The second stage is the design stage. At this stage, the design of the product to be made is carried out based on the results of the analysis that was carried out in the previous stage. At this stage, an initial draft of the product will be produced. The materials created include lesson plans, worksheets, and test instruments for problem-solving ability, self-efficacy questionnaires designed for vibration, wave, and sound materials. These have been modified to fit the structure of the integrated PBL model with the STEM approach, which focuses on how students approach problems, organize themselves to learn, lead investigations, create and present their work, and analyze and assess problem-solving procedures (Siswandari et al., 2021).

The design stage is followed by the development stage, which is the third stage. This stage is when the first draft that was created after the design stage is developed. At this point, the produced product's validity and dependability are tested as part of a feasibility test. If every statement or question on the validation sheet can be utilized to expose something that the validation sheet will measure, then the validity test of the research product can be deemed legitimate (Dewi & Sudaryanto, 2020). Three professional validators, who are University of Mataram physics education lecturers, conducted the product validity test. As for the results of the product feasibility test, the products made were in a very valid and reliable category until it could be said that the products were feasible to use or implement.

The fourth stage is the implementation stage, where the product that has been tested for feasibility is then implemented in schools, in this case the researcher chooses to implement the product developed at one of the MTs in the city of Mataram. Product implementation was carried out in class VIII C, which consisted of 39 students.

The final stage is evaluation, in which the effectiveness of the product being made can be seen. The effectiveness of the science learning tools that have been made is measured through the KPM test instrument and student self-efficacy questionnaires. The developed device can be effective if there is an increase from the pretest to the posttest. 39 class VIII C students from one of the MTs in the city of Mataram participated in the efficacy test, which was conducted on items that had been designed by involving product consumers.

*Improved Problem Solving Ability*

The level of improvement in students' problem-solving ability can be seen through the analysis of pretest and posttest scores. These pretest and posttest values are to obtain a standard gain score. Based on the analysis that has been done, it was found that the average N-gain of students is 0.81. The score obtained based on the standard gain interpretation in table 1 that the increase in students' problem-solving abilities is in the high category. The following is a summary from the increase in students' problem-solving ability using gain standards. The following is a summary of the increase in students' problem-solving abilities using gain standards.

**Table 2**. Analysis of Average Problem Solving Ability

| $\bar{X}$ Pre | $\bar{X}$ Post | N-Gain | Category |
|---|---|---|---|
| 43.81 | 88.49 | 0.81 | High |

The summary of the results of the distribution analysis of increasing students' problem solving abilities can be seen in table 3. Based on Table 3, it can be seen that some students in class VIII C have a high increase in problem solving abilities.

**Table 3**. Summary of Analysis Results for Increasing Student KPM

| Grade <g> | Classification | Total of Students | Percentage |
|---|---|---|---|
| 0.70<g<1.00 | High | 28 | 71.79 % |
| 0.30<g<0.70 | Medium | 11 | 28.21 % |
| 0.0<g<0.30 | Low | 0 | 0 % |

Meanwhile, to find out that there is an increase in students' KPM in vibration, wave, and sound material that is taught using the integrated PBL model set of the STEM approach, can be seen in the diagram below.

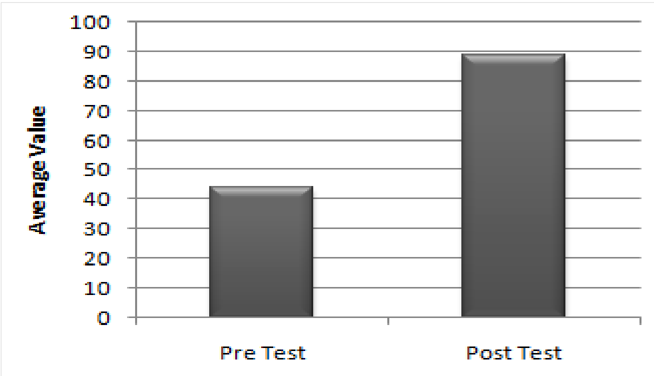


**Figure 1**. Result of improved problem solving ability

By examining the students' pretest and posttest scores, it is claimed that their problem-solving skills have increased. The average pretest results of students based on the description in Table 2 and Table 3 is 43.81 while the posttest average is 88.49 and the N-Gain is 0.81 in the high category. Where, 71.79% of students have increased problem-solving abilities in the high category and 28.21% of students have increased problem-solving abilities in the moderate category.

In general, the increase in indicator problem-solving ability is included in the high category. The four indicators of problem-solving ability used include understanding the problem, planning a solution, carrying out a solving plan, and re-examining the results of the solution. The following is a description of the results of the N-Gain analysis of problem-solving ability indicators.

**Table 4**. Analysis of Improved Problem Solving Ability Indicator

| Indicator | $\bar{X}$ Pre | $\bar{X}$ Post | N-Gain | Category |
|---|---|---|---|---|
| Understanding Problems | 67.31 | 91.03 | 0.73 | High |
| Planning Solutions | 17.95 | 92.56 | 0.91 | High |
| Doing a Solution Plan | 71.79 | 91.03 | 0.68 | Medium |
| Rechecking Solving Results | 17.69 | 79.36 | 0.75 | High |

Based on the description in Table 4, it can be seen that in the indicators of carrying out a split plan, the N-Gain results obtained are 0.68 in the medium category. This indicator has the least increase compared to other problem solving ability indicators. This is because students are not used to explaining answers in detail in the form of description questions. Therefore it is important to facilitate students to be able to practice solving problems in detail.

In light of the N-Gain findings, it can be concluded that science education resources that use the STEM approach's integrated PBL model effectively enhance students' capacity for problem-solving. Research done by strengthens this Hadi et al. (2022) and Viana et al. (2023) that STEM-integrated PBL model learning tools can improve students' problem-solving abilities.

*Self-Efficacy Improvement*

As with problem solving abilities, the level of increase in self-efficacy of students can also be known after analyzing the scores of the questionnaire results before and after learning. Where the score aims to obtain a standard gain score. Based on the calculation of the standard gain, it is obtained that the overall standard gain value of the students is 0.30 which is included in the medium category. The following is a description of the acquisition of student self-efficacy gain standards.

**Table 5**. Average Self-Efficacy Analysis

| $\bar{X}$ Pre | $\bar{X}$ Post | N-Gain | Category |
|---|---|---|---|
| 89.69 | 98.38 | 0.30 | Medium |

Then the distribution of the percentage of increased self-efficacy can be seen in Figure 2 below.

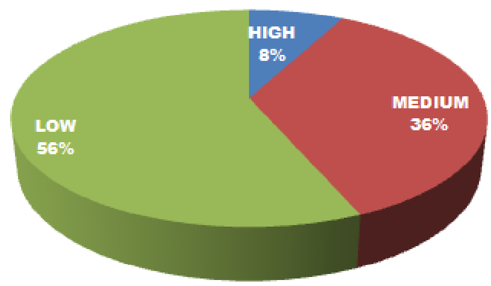


**Figure 2**. Percentage increase in self-efficacy

The increase in self-efficacy of students is measured through the results of completing questionnaires before and after learning utilizing the STEM approach and the integrated PBL paradigm. The questionnaire consists of 30 statement items, where each student's questionnaire score is then calculated using the N-Gain calculation. Based on the results of the N-Gain calculation, an average initial score of 89.69 was obtained and an average final score of 93.38 with an N-Gain value of 0.30 which was included in the medium category. The distribution of the increased self-efficacy of students before and after learning The PBL paradigm combined with the STEM methodology is 8% with a high increase in self-efficacy, 36% with a moderate increase, and 56% with a low increase in self-efficacy.

This acquisition is based on research that has been done and is reinforced by learning exercises that have been completed. Students are also facilitated to ask questions or discuss if they experience problems during learning. Besides that, it can also be due to the provision at the end of the lesson which makes them more motivated and more confident to take part in every learning activity that is carried out. The PBL paradigm has been shown to boost students' self-efficacy, according to research by Saepuloh et al. (2021). Then, studies by A also demonstrated that integrating STEM education into the classroom might raise students' self-efficacy (Muliyana & Jailani, 2023). Therefore tools for science education that combine the STEM approach and the PBL model are effective for increasing student self-efficacy. This is in line with research conducted by Setiawati et al. (2023) that the development of mathematical models using the PBL-STEM model can improve students' problem-solving abilities and self-efficacy.

## Conclusion

It is said that creating science learning resources based on the STEM approach's integrated PBL paradigm helps students become more adept at solving problems and feeling more confident in their own abilities. This is demonstrated by the students' increased problem-solving skills, which now stand at 0.81, falling into the high group, and their increased self-efficacy, which results in a standard gain score of 0.30, falling into the medium category.

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**Author Contributions**

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**Conflict of Interest**

The main source of conflict in this research is the large amount of learning time lost due to inadequate internet access during the learning process. Afterwards, students struggle to understand a few of the sentences on the interactive worksheet. Consequently, it is advised to verify internet availability prior to instruction for comparable study.

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