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# Improving Students' Computational Skills through the Implementation of Problem-Solving Laboratory Learning Models

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***Abstract*** *–Computational thinking is an essential skill for students in the digital era. These skills must be trained in physics learning activities through appropriate learning models. This study aimed to determine the implementation of the Problem Solving Laboratory (PSL) learning model and improve students' computational thinking skills on alternating current electricity. The research was conducted at one public high school in Banjar City, West Java, Indonesia. The research method used was a pre-experimental design with one group pre-test and post-test. The results showed that the average percentage of PSL model learning activities implementation was 78.4% in the effective category. The increase in students' computational thinking skills is in the high category, as evidenced by the average N-gain value of 0.73. This study concludes that the PSL learning model improves students' computational thinking skills. This research recommends implementing the PSL learning model to improve computational thinking skills in other physics topics or other fields of study.*

***Keywords:*** *alternating current; computational thinking; problem solving labolatory*



## I. INTRODUCTION

21st-century education is characterized by accelerating technological and digital revolutions that require students to build skills that can help them adapt to these changes.(Dishon & Gilead, 2021); (Oliveira & de SOUZA, 2022). In this context, computational thinking skills become a crucial element that must be learned by students (Wing, 2006). These skills function as tools for understanding and interacting with technology and as a framework for thinking that involves problem-solving, creativity, and systematic understanding (Barr & Stephenson, 2011).

Although computational thinking skills are becoming essential in the digital age, many students face significant challenges in developing these skills. One of the main problems is the lack of understanding of the basic concepts of computational thinking and how to apply them in everyday contexts (Barr & Stephenson, 2011). In addition, another obstacle is the lack of a practical teaching approach and an integrated curriculum that supports the development of these skills (Yadav et al., 2011).

The results of a preliminary study at one public high school in Banjar City, West Java, show that computational thinking skills have not been extensively trained. This is evident from the trial results using CT (Computational Thinking) questions from BEBRAS (www.bebras.or.id), where many students had difficulty completing them. The same results were confirmed in several previous studies. The study's results (Kamil, 2021) show that students' computational thinking skills are still deficient. The same thing was found by (Jamna et al., 2022). The results of his study show that as many as 35% of students are in the low category, 35% are in the medium category, only 10% are students in the high category, and 5% are in the very high category.

Several attempts have been made to improve students' computational skills, including basic programming (Santoso et al., 2020) and interactive animation media (Satria et al., 2022). Both efforts are considered too high and require adequate facilities. The need to develop learning models to improve computational thinking skills has been analyzed (Putri et al., 2022). According to (Batul et al., 2022), computational thinking skills can be trained through learning activities with problem-solving stages. One of the learning activities with problem-solving stages is the Problem Solving Laboratory (PSL) model.

The PSL model is expected to improve computational thinking skills because it has stages that can involve students actively in solving a problem and being able to develop higher-order thinking skills (Malik et al., 2019). This study aimed to measure the implementation of the PSL learning model and its effect on improving students' thinking and computational skills.

## II. METHODS

The research method used was a pre-experimental design with one group pretest-post test, as shown in Table 1.

**Table 1**. One group pretest-post test design

| $O_1$ | X | $O_2$ |
|---|---|---|

with:

$O_1$ = pretest

X = PSL learning model

$O_2$ = post test

The research sample was 35 class XII students at one high school in Banjar City, West Java, Indonesia. The procedure of this research is shown in Figure 1.

Two data were collected in this study, namely (1) the implementation of the PSL model learning process and (2) the improvement of students' computational thinking skills. The first data is collected through Authentic Assessment based on Teaching and Learning Trajectory with

Student Activity Sheets (AABTLT with SAS) (Rochman et al., 2017). The second data was obtained through a computational thinking test in the form of a description question on alternating current electricity. The measured computational indicators are decomposition, abstraction, pattern recognition, algorithmic thinking, and collecting & data analysis (Parlons Sciences, 2018).

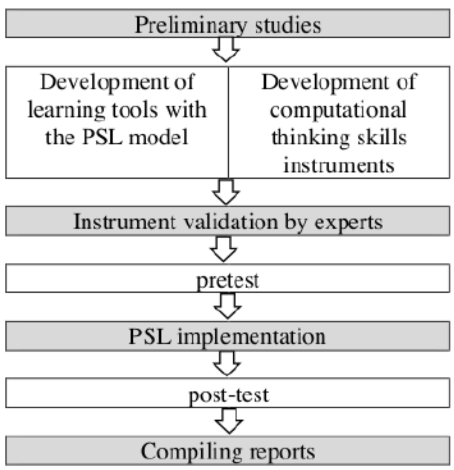


**Figure 1.** Research procedure

Data on the implementation of AABTLT with SAS, which contains students' responses, are then calculated according to the assessment rubric as follows (Nasrudin et al., 2017).

**Table 2.** Rubric of AABTLT with SAS

| Score | Criteria |
|---|---|
| 0 | If the respondent does not provide an answer |
| 1 | If the respondent gives a wrong answer |
| 2 | If the respondent gives a correct but incomplete answer. |
| 3 | If the respondent answers correctly and completely but not as expected. |
| 4 | If the respondent's answer is correct, complete, and as expected. |

SAS sheets that have been assessed are then accumulated for each stage of learning. The assessment results are then made into a percentage that can be searched through Equation 1.

$$\% = \frac{The\ score\ obtained}{Maximum\ score} \times 100\% \quad (1)$$

(Nasrudin et al., 2017)

The results of calculating the percentage are then interpreted based on the criteria for learning effectiveness, as shown in Table 3 (Nasrudin et al., 2017).

**Table 1.** The Interpretation of AABTLT with SAS

| Percentage (%) | Interpretation |
|---|---|
| <55 | Not Effective |
| 55-70 | Less Effective |
| 71 – 85 | Effective |
| >85 | Very Effective |

The improvement in computational thinking skills can be known through the average normalized gain value (<g>) which can be found through Equation 2.

$$< g > = \frac{\% <G>}{\%<G>_{max}} = \frac{\%<S_f>-\%<S_i>}{(100-\%<S_i>)} \quad (2)$$

(Hake, 1998)

where $S_f$ and $S_i$ are the final (post) and initial (pre) class averages. The results of <g> were then confirmed according to the criteria put forward by (Hake, 1998) as shown in Table 4.

**Table 4.** Criteria for average normalized gain.

| <g> | criteria |
|---|---|
| (<g>) > 0.7 | high |
| 0.7 > (<g>) > 0.3 | medium |
| (<g>) < 0.3 | low |

## III. RESULTS AND DISCUSSION

This study answered two research questions: the implementation of the PSL model and the improvement of students' computational thinking skills. The research results for answering the first question are presented in Table 5, while the results for the second question are shown in Table 6 and Table 7.

**Table 5.** The implementation of PSL

| Lear.to | The implementation of PSL (%) | Interpretation |
|---|---|---|
| 1 | 76,3 | Effective |
| 2 | 78,7 | Effective |
| 3 | 80,1 | Effective |
| Avg. | 78,4 | Effective |

The data shown in Table 5 are the processing results of the SAS with the rubric shown in Table 2, accumulated through equation (1) and confirmed with the standards in Table 3. The data in Table 5 indicate the implementation of PSL learning. In general, the implementation of PSL is effective, with an average achievement rate of 78.4%.

The effectiveness of the implementation of the PSL model can be associated with several important aspects in the learning process. *First,* the PSL model focuses on a problem-solving approach that encourages students to think critically and analytically. Within a laboratory environment, students are given the opportunity to actively engage in experiments and investigations (Gürses et al., 2007). This not only enables them to understand concepts in depth but also to develop practical skills in applying their knowledge. *Second,* an achievement rate of 78.4% indicates that the majority of students can meet or even exceed the set learning objectives. This is a good indicator that the PSL model is able to adapt to the learning needs of students and provide adequate support to help them achieve the desired outcomes. The active involvement of students in the learning process is one of the key factors that may have contributed to this high success rate (Wilujeng & Suliyanah, 2022).

However, it is also important to consider that there is still room for improvement. For example, additional strategies such as the use of technology or a more diverse range of learning materials can be integrated into the PSL model to further enhance its effectiveness. In the future, it is necessary to design project-based experiments to train students to be more creative (Sari et al., 2020), modified student activity sheets (Rahayu et al., 2018), or through the help an Android-based pocketbook as a guide tool (Mulhayatiah et al., 2019).

This research was conducted with three lessons using the PSL model. The syntax of the PSL consists of the PSL model composed of three learning stages: the opening or pre-experimental activities; core activities or experimental stage; and post-experiment closing activities (Heller & Heller, 2012). The findings in the field showed that the implementation of PSL at the initial meeting was complex. Students are unfamiliar with the PSL learning model, especially in the experimental phase.

The difficulties faced by students in adapting to the PSL model, especially during the experimental phase, may be due to several factors. First, because the PSL model may be different from the traditional learning methods they are accustomed to, students may have difficulty understanding how this model works and what is expected of them. PSL requires active involvement of students in problem-solving through experimentation, which may be a new approach for many students.

Furthermore, the complexity that occurs in the experimental phase can also be caused by the lack of practical skills and laboratory experience possessed by the students. The experimental phase in the PSL model generally involves the use of laboratory equipment and data collection techniques that students may not have encountered before. This demands a good understanding of scientific principles and technical skills that the students may not have developed.

To overcome these challenges, it is important for educators to provide the necessary support to students, especially in the early stages of implementing the PSL model. This can include an introduction to the basic concepts of the PSL model, demonstrations on how to use laboratory equipment, and guidance in developing problem-solving strategies. In addition, educators can provide constructive feedback and encourage collaboration among students to build a supportive learning environment (Kadir et al., 2020).

Regarding the improvement of students' computational thinking skills after being given learning with the PSL model, Table 6 shows it. The results in Table 6 are the data processing results using equation (2) and are confirmed based on the criteria established in Table 4.

**Table 6.** Improvement of Students' Computational Thinking Skills.

| Average Pre-test | Average Post-Test | Average N-gain |
|---|---|---|
| 40,0 | 82,97 | 0,73 |

Based on data from Table 6, the increase in students' computational thinking skills is in the high category. Computational thinking involves logical reasoning, problem-solving, and the ability to understand and solve complex problems through systematic methods. The PSL model fosters an environment where students are actively engaged in solving real-world problems through experimentation.

Through PSL model, students are not just passive recipients of information but are encouraged to think critically and systematically in problem-solving. This involves breaking down problems, analyzing them, and applying various methodologies to find solutions (Asdar et al., 2020). Such an approach aligns closely with the principles of computational thinking.

By implementing the PSL model, educators can create a more interactive and practical learning environment. This not only makes the learning process more engaging but also helps in developing essential skills that are critical in today's technology-driven world. The data in Table 6 is a testament to the effectiveness of the PSL model in fostering these invaluable computational thinking skills among students. These results strengthen previous research's effects on PSL's benefits and advantages. PSL has been proven to increase student creativity (Azizah & Edie, 2014), problem-solving skills (Leite & Dourado, 2013), scientific literacy (Muhajir et al., 2015), and metacognition skills (Mariati, 2012).

The average results of pretest, posttest, and N-gain for each indicator of Computational Thinking Skills (CTS) can be seen in Table 7.

**Table 7.** Improvement of each CTS indicator

| CTS Indicator | Average | | |
|---|---|---|---|
| | Pre | Post | N-gain |
| Decomposition | 48,2 | 86,5 | 0,74 |
| Abstraction | 42,5 | 87,9 | 0,79 |
| Pattern Recognition | 34,3 | 79,2 | 0,68 |
| Algorithmic Thinking | 36,9 | 80,1 | 0,68 |
| Data Analysis | 38,1 | 81,1 | 0,70 |

The data in Table 7 shows that students' skills in the computational thinking skill component vary greatly. Abstraction ability is the best skill, while pattern recognition and algorithmic thinking are the lowest. Abstraction ability is the process in which students are able to simplify complex problems into a more straightforward form, thereby facilitating understanding and problem-solving. This data is good news considering that abstraction is a crucial skill for processing (Kramer, 2007). On the other hand, pattern recognition is related to the ability to identify and understand patterns that emerge in data or problems, and algorithmic thinking involves creating systematic steps to solve problems.

The fact that abstraction ability is the strongest skill possessed by students suggests that they may be able to comprehend concepts at a higher level, but might face difficulties in applying systematic processes and recognizing patterns in information. This may indicate that there needs to be a greater emphasis on the development of pattern recognition skills and algorithmic thinking in the curriculum and learning approaches. Although reworking thinking skills is regarded as a new skill in learning science, packaging easy learning, including videos, will be an alternative method of embedding these skills (Irwansyah et al., 2019); (Suhendi et al., 2023).

The results of this study have implications for learning physics in general. This study shows that the PSL model can be an effective tool for developing computational thinking skills. Given the importance of computational thinking skills in today's digital era, this learning model can be an important way to prepare students with the skills needed in the 21st century. In practice, physics teachers can consider applying the PSL learning model in their learning, especially on alternating current and perhaps other topics, to support the development of students' computational thinking skills.

## IV. CONCLUSION AND SUGGESTION

This research has proven that applying the Problem Solving Laboratory (PSL) model can improve students' computational thinking skills in alternating current electricity material. Implementing physics learning activities with the PSL model has an average percentage of 78.4% with a practical interpretation. The results of the N-gain calculation show that students experience an increase in computational thinking skills after applying the PSL model of 0.73 in the high category.

This study has weaknesses, including pre-experimental methods that do not use a control class. The following research is essential to use the control class and use it in a broader style to test the effectiveness of PSL in improving students' computational skills.

This study suggests further testing of the effectiveness of the PSL model in improving computational thinking skills on other physics topics or other fields of study.

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