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# IMPROVING MATHEMATICAL PROBLEM-SOLVING SKILLS THROUGH CREATIVE PROBLEM-SOLVING INSTRUCTION: EVIDENCE FROM A CONTROL AND EXPERIMENTAL GROUP STUDY

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**Abstract**

Students' mathematical problem-solving ability is still at a low level, which is indicated by their difficulty in solving mathematical problems creatively. This condition is closely related to the learning process in the classroom, where conventional teaching methods are still dominantly applied, resulting in students' learning outcomes not reaching the minimum mastery criteria (KKM). This study aims to examine the effect of the Creative Problem Solving (CPS) learning model as a structured learning approach that emphasizes systematic problem identification, idea generation, and solution development based on students' creativity to produce effective problem-solving outcomes. This study employed a quasi-experimental research design with a purposive sampling technique. The research population consisted of tenth-grade students at Senior High School 09, located on Jl. Cemara Raya, Padangsari, Banyumanik District, Semarang City, Central Java. The sample involved two classes, namely class X IPA-3 with 35 students as the experimental group and class X IPA-2 with 36 students as the control group. The research instruments included written tests to measure students' mathematical problem-solving abilities, learning outcome tests, and observation sheets to evaluate the implementation of the learning process. Data were analyzed using descriptive and inferential statistical techniques. The results of data analysis showed that the calculated t-value ($t_{cal} = 4.925$) was greater than the t-table value ($t_{table} = 1.666$), leading to the rejection of the null hypothesis. These findings indicate that the Creative Problem Solving learning model has a significant effect on students' mathematical problem-solving abilities.

**Keywords:** creative problem solving; mathematical problem-solving ability; learning model.

## INTRODUCTION

Mathematics is a fundamental discipline that plays a crucial role in the development of science and education. It is often referred to as *the Queen of Sciences* because of its contribution to shaping scientific thinking and reasoning skills. Mastery of mathematics requires not only cognitive ability but also students' interest and persistence in the learning process. Through mathematics learning, students are trained to develop logical, analytical, and critical thinking skills that are essential for solving problems in both academic and real-life contexts. Recognizing the strategic role of mathematics, the Indonesian education curriculum allocates a greater proportion of instructional time to mathematics compared to other subjects.

Despite its importance, Indonesian students' ability to solve mathematical problems, particularly non-routine story problems, remains relatively low. Many students experience difficulties in understanding problems and formulating appropriate solution strategies. According to Schleicher (2019), based on the results of the Programme for International Student Assessment (PISA) 2018, Indonesia ranked 72nd out of 78 participating countries, with an average mathematics score of 379. Furthermore, Fauzi and Abidin (2019) explain that the mathematical competencies assessed in PISA include identifying problems, selecting relevant information, applying appropriate problem-solving strategies, and generalizing solutions. These competencies are closely related to indicators of critical thinking skills, indicating that Indonesian students' mathematical critical thinking ability is still at a low level.

One contributing factor to students' low mathematical problem-solving ability is the learning process, which has not sufficiently encouraged creative thinking. Rostika and Junita (2017) point out that mathematics instruction often emphasizes the use of quick formulas, enabling students to solve routine conceptual problems rather than engaging them in meaningful problem-solving activities. As a result, students tend to rely on memorization rather than developing reasoning and creativity. Previous studies have shown that the application of the Creative Problem Solving (CPS) learning model can enhance students' creative thinking abilities in mathematics. The use of CPS has been reported to improve teacher performance, student participation, as well as students' attitudes and skills in each learning cycle. Moreover, the CPS learning model has a positive and significant impact on students' thinking patterns, particularly in solving mathematical problems.

Based on interviews conducted with mathematics teachers and students at the research site, it was found that students' average achievement was still below the expected standard. This condition was largely attributed to the continued use of conventional teaching methods, which limited students' active participation and resulted in learning outcomes that did not meet the minimum mastery criteria (KKM). Therefore, an appropriate learning model and strategy are needed to enhance students' mathematical problem-solving abilities, encourage active learning, and ensure that instructional objectives are achieved (Rofiqoh & Rochmad, 2016).

To address these challenges, a shift from teacher-centered learning to student-centered learning is essential. Learning experiences should be designed to connect mathematical content with real problems while optimizing the use of learning resources. Actively involving students in the learning process is expected to improve learning outcomes and enhance their ability to think critically when solving problems (Aljaberi & Gheith, 2016). Considering these issues, selecting an appropriate learning model becomes a key effort in improving students' mathematical problem-solving skills. Shoimin (2017) describes the Creative Problem Solving (CPS) model as an instructional approach that emphasizes problem-solving skills followed by reinforcement of those skills. Similarly, Ngalimun (2017) explains that CPS is a variation of problem-based learning that applies systematic techniques to organize creative ideas in solving problems. This view is supported by Helen and Kusdiwelirawan (2022), who state that CPS is an effective learning model for developing students' creative thinking abilities, as it encourages learners to examine problems from multiple perspectives and determine the most appropriate solutions through careful reasoning.

According to Novitasari (2015), the CPS model offers several advantages in problem solving, including training students to design innovative solutions, think and act creatively, solve problems realistically, conduct investigations, and interpret and evaluate observational results. This perspective aligns with the findings of Wasiran and Andinasari (2019), who emphasize that the CPS model enables students to express ideas fluently and generate multiple alternative solutions, allowing them to solve problems from various perspectives with different representations.

Based on the discussion above, this study aims to examine the Creative Problem Solving learning model as a systematic approach to problem solving that emphasizes students' creativity in producing effective solutions in mathematics learning.

## RESEARCH METHOD

This study employed a **quasi-experimental research design**. The research was conducted in one senior high school by involving two classes, consisting of one experimental class and one control class. The experimental class received learning treatment using the **Creative Problem Solving (CPS) learning model**, while the control class was taught using **conventional learning methods** commonly applied by teachers. The quasi-experimental design implemented in this research was a **non-equivalent control group design**. The research procedure included conducting interviews with mathematics teachers to obtain preliminary information regarding the learning process, followed by administering an initial test (**pre-test**) and a final test (**post-test**) to both groups. The assessment instrument used in this study was an essay-type test consisting of **four items** designed to measure students' **mathematical problem-solving abilities** on **linear inequality material**.

Data analysis in this study comprised **descriptive statistical analysis** and **inferential statistical analysis**. Descriptive analysis was carried out based on observation sheets and by calculating the mean scores of students' learning outcomes in both the experimental and control classes using pretest and posttest data. Meanwhile, inferential analysis was conducted to examine differences in mathematics learning outcomes between the two groups. The inferential analysis utilized pretest and posttest data through three stages: **(1) normality testing**, **(2) homogeneity testing**, and **(3) hypothesis testing using an independent samples t-test**.

The research was conducted at **State Senior High School 09**, located on **Jl. Cemara Raya, Padangsari, Banyumanik District, Semarang City, Central Java**. The study took place during the **odd semester of the 2022/2023 academic year**, focusing on linear inequality topics. The population of this research included all students at the same grade level in the school. Sampling was conducted using a **purposive sampling technique**. According to **Sugiyono (2016)**, purposive sampling is a method of determining samples based on specific considerations. The sample in this study is two classes, namely one class XIPA-3 with 35 students as an experimental class and one class XIPA-2 with 36 students as a control class The research design is presented in Table 1.

**Table 1. Research Design**

| Class | Pre-Test | Treatment | Post-Test |
|---|---|---|---|
| **Experimental** | O1 | X | O2 |
| **Control** | O1 | – | O2 |

Source: Sugiyono (2016)

Based on Table 1, students' mathematical problem-solving abilities were measured using written tests administered before and after the learning intervention. The test instruments consisted of four essay questions that assessed students' problem-solving skills related to linear inequality material.

## RESULT AND DISCUSSION

### 1. Research Results

Table 2. Statistical Analysis of Mathematical Problem Solving Ability

| | Min | Max | Mean | Stdev |
|---|---|---|---|---|
| Experimental Pre-Test | 58 | 78 | 68.72 | 6.386 |
| Experimental Post-Test | 63 | 92 | 76.44 | 6.078 |

| | | | | |
|---|---|---|---|---|
| Control Pre-Test | 60 | 80 | 69.19 | 6.697 |
| Experimental Post-Test | 62 | 83 | 69.44 | 5.983 |

The analysis of students' mathematical problem-solving abilities based on the pretest and posttest scores is presented in **Table 2**.

**Table 2** shows that the average pretest score of the experimental class was **68.72**, while the control class obtained a slightly higher average score of **69.19**. These results indicate that both groups had relatively similar initial abilities before the treatment was implemented. However, after the learning intervention, a noticeable difference appeared in the posttest results. The experimental class, which applied the Creative Problem Solving (CPS) learning model, achieved an average posttest score of **76.44**, whereas the control class, which received conventional instruction, obtained an average score of **69.44**. The increase in posttest scores in the experimental class was higher than that of the control class, indicating better improvement in students' mathematical problem-solving abilities after the application of the CPS learning model. Nevertheless, descriptive statistical analysis alone is insufficient to determine whether the CPS learning model has a significant effect on students' mathematical problem-solving abilities. Therefore, further inferential statistical analyses were conducted, beginning with the normality test.

The normality test aims to determine whether the data are derived from a normally distributed population (Septian, 2017). The hypotheses for the normality test are formulated a follows $H_0$: The data come from a normally distributed population. $H_1$: The data do not come from a normally distributed population.

The normality test was performed using the Kolmogorov–Smirnov test with the assistance of IBM SPSS Statistics version 20 at a significance level of 5% ($\alpha = 0.05$). The decision criteria are as follows:

(a) If the significance value (Sig.) ≥ 0.05, then $H_0$ is accepted.

(b) If the significance value (Sig.) < 0.05, then $H_0$ is rejected.

The results of the normality test for the pretest and posttest data are presented in **Table 3**.

Table 3. Normality Test

| **CLASS** | **Kolmogorov-Smirnov[a]** | | **Keterangan** |
|---|---|---|---|
| | Significant | | |
| | Pre-Test | Post-Tes | |
| **Eksperiment** | 0.209 | 0.210 | Normal |

| Control | 0,208 | 0,114 | Normal |
|---|---|---|---|

Based on the results shown in **Table 3**, the significance value of the pretest data for the experimental class was **0.209**, while that of the control class was **0.208**. Both values exceed 0.05, indicating that the pretest data are normally distributed. Similarly, the posttest data also met the normality assumption, with significance values of **0.210** for the experimental class and **0.114** for the control class. Thus, it can be concluded that the pretest and posttest data from both classes are normally distributed. After confirming the normality of the data, a homogeneity test was conducted to examine whether the variances of the two groups were equal. The results of the homogeneity test are presented in **Table 4**.

Table 4. Homogenity Test

| | **Levene Statistic** | **df1** | **df2** | **Sig.** |
|---|---|---|---|---|
| **ExperimenT** | 0.12 | 1 | 70 | 0.715 |
| **Control** | | | | |

Based on **Table 4**, the significance value obtained from the homogeneity test was **0.715**, which is greater than the significance level of 0.05. This result indicates that the variances of the experimental and control classes are homogeneous. Having satisfied both the normality and homogeneity assumptions, the analysis proceeded to the independent samples t-test. The independent samples t-test was conducted to determine whether there was a significant difference in mathematical problem-solving abilities between students who were taught using the CPS learning model and those who received conventional instruction. The results of the hypothesis testing using SPSS version 25 are presented in **Table 5**.

Table 5. hypothesis test

| **Kelas** | $t_{count}$ | $t_{table}$ | **statement** | **Hipotesis** |
|---|---|---|---|---|
| Experiment Control | 4.915 | 1,666 | $t_{hitung} > t_{tabel}$ | $H_0$ Rejected |

Based on **Table 5**, the calculated t-value (t_calculated = **4.915**) is greater than the critical t-value (t_table = **1.666**). Therefore, $H_0$ is rejected. This result indicates that there is a significant and positive effect of the Creative Problem Solving (CPS) learning model on the mathematical problem-solving abilities of Grade X students at SMAN 1 Rantau Utara. Consequently, it can be concluded that students who learned through the CPS model achieved better mathematical problem-solving performance than those who followed conventional learning.

**2. Discussion**

**The Influence of the Creative Problem Solving Learning Model**

Based on the findings of the study and the results of statistical analyses, it can be concluded that the Creative Problem Solving (CPS) learning model has a positive influence on students' thinking processes in solving mathematical problems. The descriptive results indicate that the average pretest scores of the experimental class (**68.72**) and the control class (**69.19**) were relatively similar, suggesting comparable initial abilities between the two groups. However, after the learning intervention, the experimental class demonstrated a greater improvement in posttest scores (**76.44**) compared to the control class (**69.44**). This difference reflects the effectiveness of the CPS learning model in enhancing students' mathematical problem-solving abilities.

In this study, two different instructional approaches were implemented. The experimental class was taught using the CPS learning model, while the control class received conventional instruction. During the implementation of the CPS learning model, students were provided with student worksheets (LKS) and encouraged to solve mathematical problems collaboratively through small-group discussions that had been predetermined by the teacher.

Observations conducted during the learning process revealed that students in the experimental class were generally more active in understanding the material and engaging in problem-solving activities. Compared to the control class, students in the experimental class demonstrated higher levels of participation, interaction, and engagement. The CPS learning model facilitated active discussion among group members, allowing students to exchange ideas and contribute meaningfully to the learning process rather than acting merely as passive recipients.

In contrast, learning activities in the control class were predominantly teacher-centered. The teacher played a major role in delivering the material, providing example problems, and assigning practice questions similar to the given examples. As a result, students tended to be passive and had limited opportunities to interact with peers or express their ideas, which may have hindered the development of their problem-solving skills.

**Mathematical Problem-Solving Ability**

The results of the homogeneity and variance tests indicate that both the experimental and control classes had equal variances, as evidenced by the homogeneity test significance value of **0.715**, which exceeds the threshold of 0.05. This confirms that the two groups were statistically comparable. Furthermore, the hypothesis testing results show that the calculated t-value (**4.915**) is greater than the critical t-value (**1.666**), leading to the rejection of $H_0$. These findings provide strong statistical evidence that the CPS learning model has a positive effect on students' mathematical problem-solving abilities. Thus, students who were taught using the CPS learning model achieved significantly better outcomes than those who experienced conventional instruction.

The findings suggest that the CPS learning model enables students to actively engage in solving mathematical problems by encouraging interaction, idea sharing, and collaboration. Through this approach, students are no longer passive observers but active participants in the learning process. These results are consistent with previous studies. Nur et al. (2017) reported that the implementation of the CPS learning model improves students' problem-solving abilities, enhances student activity, and supports teachers' effectiveness in managing learning. Similarly, Lubis et al. (2018) found significant differences in students' mathematical problem-solving abilities between those taught using the CPS model and those taught using conventional methods. In addition, Widodo and Kartikasari (2017) demonstrated that learning outcomes in experimental classes using CPS were higher than those in control classes. Collectively, these findings reinforce the conclusion that the CPS learning model is effective in improving students' mathematical problem-solving abilities.

**Conclusion and Recommendations**

Based on the formulation of the research problem, the findings, and the discussion, it can be concluded that the **Creative Problem Solving (CPS) learning model has a significant influence on students' mathematical problem-solving skills**. This is evidenced by the post-test results, where students in the experimental class taught using the CPS learning model achieved a higher average score of **76.44** with a standard deviation of **6.386**, compared to students in the control class who were taught using conventional learning models, with an average score of **69.44** and a standard deviation of **5.983**. These results indicate that the CPS learning model is more effective than conventional learning approaches in enhancing students' ability to solve mathematical problems. Furthermore, students' mathematics learning outcomes related to problem-solving skills through the implementation of the CPS learning model were superior to those of students who experienced conventional instruction. This finding confirms that the use of the CPS learning model positively contributes to the improvement of students' mathematical problem-solving abilities.

Based on these findings, several recommendations can be proposed. Students are encouraged to engage more actively in solving non-routine mathematical problems and to maintain a positive attitude toward the mathematics learning process. Teachers are advised to create a more engaging learning atmosphere by implementing innovative instructional strategies, with the CPS learning model serving as a valuable reference in mathematics instruction. In addition, future researchers are expected to conduct further studies related to mathematical problem-solving skills or to explore the application of the CPS learning model in different educational contexts.

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