Jurnal Pengembangan Pembelajaran Matematika (JPPM)
Volume 7, Issue 2, August 2025
Available online at: https://ejournal.uin-suka.ac.id/tarbiyah/jppm/index
Print ISSN : 2656-0240, Online ISSN : 2655-8750

DIFFERENCES IN MATHEMATICAL PROBLEM-SOLVING SKILLS BASED ON COMPUTATIONAL THINKING IN PROBLEM-BASED LEARNING AND CONVENTIONAL LEARNING

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Received: 23-01-2025	*Revised: 20-06-2025*	*Accepted: 24-06-2025*

ABSTRACT

Problem solving ability with Computational Thinking strategy is important for students. The study aims to determine the differences in mathematical problem solving ability with computational thinking on statistics material through the Problem Based Learning (PBL) model and conventional methods in class VII MTs Daarul Uluum Blitar. The study was conducted with a quasi-experiment through a pretest-posttest design with nonequivalent control group. Saturated samples were used in the study with class VII-B as the experimental class by implementing PBL and class VII-C as the control class. Data collection was carried out with a computational thinking ability test: decomposition, pattern recognition, abstraction, and algorithms to solve mathematical problems on statistics material. An independent sample t-test was conducted to answer the problem formulation. The results showed a significance value (2-tailed) of 0.019 ($\alpha < 0.05$), with an average pretest and posttest of the experimental class of 49 and 63, while the control class was 32 and 54. These findings indicate that the PBL model is effective in improving mathematical problem solving abilities based on computational thinking.

Keywords: differences, problem solving ability, problem based learning, computational thinking.

How to cite

Fuadah, A.S., Mukti, T.S., Firmansyah, A. (2025). Differences in mathematical problem-solving skills based on computational thinking in problem-based learning and conventional learning. Jurnal Pengembangan Pembelajaran Matematika, 7(2) 122 -133. https://doi.org/10.14421/jppm.2025.72.122-133

INTRODUCTION

One of the individual needs in responding to global competition is the fulfillment of various relevant skills and abilities. Various abilities can be developed through a systematic and continuous learning process. In the current learning process, one of the skills that must be developed is computational thinking (CT) ability. Computational thinking is a form of computational thinking that aims to solve complex problems (Kawuri et al., 2019). Another definition of computational thinking is an approach to thinking that utilizes the basic principles of computer science to solve problems, design systems, and understand human behavior (Wing 2006; Elmawati et al. 2024).

Computational thinking is closely related to mathematics. Mathematics is a discipline that relies on logical and structured thinking, which is also the main basis for computational thinking (Irawati & Hadi, 2025). Computational thinking can be applied as an effort to improve the quality of the mathematics learning process. In problem solving, students construct algorithms when they observe and identify patterns in mathematical concepts (Maharani et al., 2020). CT has an important role in the context of students' understanding of abstract mathematical concepts, so that through the application of CT such as pattern recognition and algorithm design, students can build systematic thinking skills needed to solve complex mathematical problems (Fernandez et al., 2018; Marethi et al., 2024).

To realize the development of CT abilities optimally, efforts can be made in learning by implementing a model (Problem Based Learning or PBL). The PBL model is a learning activity that is oriented towards problem solving, especially those related to the application of learning materials in real life (Anggiana, 2019). The results of research by Risdiany et al. (2022) revealed that the application of PBL can train students to find solutions independently so that they are able to develop problem-solving skills effectively. Research by Anggiana (2019) states that the implementation of PBL involves students in activities that allow them to build knowledge directly. In line with this Arends (2012) emphasized that with PBL students will gain understanding through their own experiences, both using manipulative media and through direct interaction with the educational environment.

Analysis of needs in the pre-research series at MTs Daarul Uluum, researchers found that there were several problems related to the implementation of learning. The main problem is that the mathematics learning process at MTs Daarul Uluum has not consistently implemented PBL in every learning. Another problem is the results of student abilities that are relatively less than optimal. This problem is based on the lack of teacher experience in organizing classes dynamically and the low participation of students in learning which has an impact on the low ability of students to solve various mathematical problems. In the pre-research through observation, this was also strengthened by the testimony of the mathematics teacher who had been interviewed. Students have not been able to solve problems systematically, so that the conceptual framework of computational thinking in various situations cannot be carried out by students. These various situations can be in the form of giving different problems and it is indicated that students do not solve the problem.

In solving mathematical problems through computational thinking, students can do it through learning experiences supported by good learning planning. However, in practice, the learning process does not always go according to plan. Students often face various challenges and obstacles that can disrupt the smoothness of learning and hinder the achievement of predetermined goals. This is strengthened in the research of Augie et al. (2023) that there are learning barriers in solving problems in statistical material related to computational thinking skills. Based on the analysis of student answers and interviews, obstacles were found in pattern recognition and abstraction which were often caused by limitations in understanding the context of the problem. In addition, obstacles were also found in the form of didactic obstacles caused by the limitations of the learning given to students that did not emphasize computational thinking skills.

In order to address existing problems, good problem-solving skills are needed. According to Polya (1973), problem solving is an effort to find solutions to difficulties in order to achieve goals that are not easily achieved directly. This ability allows students to apply knowledge to solve real problems (Litia et al., 2023). Istiyono et al. (2019) mphasized the importance of this skill, especially in science and mathematics subjects, because it supports decision-making and the development of skills that are relevant to everyday life. For example, in statistical material, mastery of concepts can be used for practical needs such as calculating average monthly income and expenses. Ruseffendi (1991) also stated that problem-solving skills are not only important in mathematics, but are also relevant in various fields and life situations.

In mathematics learning, problem solving is closely related to computational thinking. Solving mathematical problems using computational thinking can be done by applying four indicators, including: decomposition, pattern recognition, abstraction, and algorithms (Lee et al., 2014). Supiarmo (2021) added that computational thinking has four main indicators used in the problem-solving process as the problem-solving steps according to Polya (2004) including: understanding the problem, developing a strategy, implementing a plan, and re-checking. In his research, Supiarmo (2021) implemented computational thinking indicators in the problem-solving stages. The stages of problem solving are in line with the computational thinking indicators, namely: 1) understanding the problem: decomposition, 2) developing a strategy: pattern recognition, 3) implementing a plan: abstraction and algorithmic thinking, and 4) re-checking (Lee et al., 2014; Polya, 2004; Supiarmo, 2021). In solving mathematical problems, it must be in accordance with computational thinking procedures.

Computational thinking is one method to improve students' problem-solving abilities (Megawati et al., 2023). Computational thinking involves a logical reasoning process that allows students to solve problems in a structured manner (Csizmadia et al., 2015). This approach is very relevant in data analysis or problem solving based on the information provided (Anggrasari, 2021). Azmi & Ummah (2021) added that solving problems with computational thinking requires structured and systematic steps that are in accordance with certain indicators.

In mathematics, statistics is one of the materials that involves the computational thinking process. Problem solving in statistics material is often done with computational thinking, as stated by Augie et al. (2023), which states that statistics is a junior high school mathematics material that is relevant to computational thinking skills. Statistics is a mandatory material in grade VII of junior high school which includes knowledge of data and diagrams, such as numerical data, categorical data, bar charts, line charts, and pie charts (Kemdikbudristek, 2022). However, some students still face various obstacles in solving problems in this material. According to Yusuf et al. (2017) students often have difficulty in answering problem-solving questions in statistics, either due to a lack of understanding of basic statistical concepts or an inability to apply systematic logical thinking strategies.

The obstacles faced by students in statistics can be caused by several factors (Maharani et al., 2022; Nugraha & Basuki, 2021). First, many students have difficulty understanding basic statistical concepts, such as data types and diagram interpretation. Second, students are less accustomed to applying computational thinking processes that involve logical and structured steps in solving problems. In addition, the learning models applied by teachers are often less interactive and do not emphasize the application of statistical concepts in real-life contexts

(Manullang et al., 2023). Based on this, effective solutions are needed to improve students' problem-solving abilities in statistics material. Research by Augie et al. (2023) and Supiarmo (2021) how's that the application of computational thinking in statistics learning has great potential to improve students' understanding, especially when combined with learning models such as Problem Based Learning (PBL). This is because PBL can maximize students' thinking potential to be more honed and tested and developed (Tan, 2003).

For that reason, the researcher conducted a study aimed at determining the differences in mathematical problem-solving abilities based on computational thinking on data and diagram materials in grade VII through the application of the Problem Based Learning model. This study is entitled "Differences in Mathematical Problem-Solving Abilities Based on Computational Thinking in Problem Based Learning and Conventional Learning".

METHOD

This study uses a quantitative approach with a quasi-experimental method to obtain valid data. The design applied is a pretest-posttest with nonequivalent control group design, the details of which are presented in Table 1.

Table 1. Action Scheme

Class	*Pretest*	Action	*Posttest*
Experiment	T1	Xe	T2
Control	T1	-	T2

with

X_E : implementation of the Problem Based Learning (PBL) model

\- : conventional learning

T1 : Pretest in the experimental and control classes.

T2 : Post-test in the experimental and control classes

The research was conducted at MTs Daarul Uluum Blitar with sample determination using saturated sampling, namely the entire population used as a research sample. Determination of experimental and control classes was done randomly. Class VII-B as an experimental group by implementing the Problem Based Learning (PBL) model, while class VII-C as a control group with a conventional learning approach. The research instrument was an essay test, consisting of 4 questions for the pretest and 4 questions for the post-test, which were specifically designed to measure mathematical problem-solving abilities based on computational thinking. Indicators of solving mathematical problems with CT used include decomposition, pattern recognition, abstraction, and algorithms (Lee et al., 2014). Data collection was carried out through pretest and post-test and analysed using the independent sample t-test.

RESULTS AND DISCUSSION

RESULTS

The results of the analysis of research data on students' mathematical solving abilities through CT applied through PBL learning are presented in Table 2 as follows.

Table 2. Normality test of pretest-posttest of experimental and control classes

Class	*Saphiro Wilk*		
	Statistic	***df***	***Sig.***
Pretest control	0,938	23	0,165
Posttest control	0,945	23	0,233
Pretest experiment	0,924	23	0,081
Posttest experiment	0,948	23	0,271

Table 2 results of the normality test using the Shapiro-Wilk method show the significance values obtained from the pretest and post-test in the experimental and control classes. In the normality test, data is considered normally distributed if the significance value produced is equal to or greater than 0.05. In the control class, the significance value obtained was 0.165 for the pretest and 0.233 for the post-test. Likewise in the experimental class, the pretest significance value was recorded at 0.081, while the post-test was 0.271. These results indicate that the pretest and post-test data in both classes, both experimental and control, have a normal distribution because the significance value meets the criteria (≥ 0.05).

A homogeneity test is carried out to determine whether the samples used come from a uniform population. Data is said to be homogeneous if the samples have similar characteristics and come from the same population. By using statistical analysis through the SPSS version 25.0 application, the results of the data homogeneity test are presented in Table 3.

Table 3. Homogeneity test of experimental and control classes

Levene Statistic	df1	df2	Sig.
0,712	1	44	0,403

The basis for data decision making can be said to be homogeneous if the significance value is greater than or equal to 0.05. Based on Table 3, the significance value obtained is 0.403, so it can be concluded that the data obtained from this study is proven to be homogeneous or comes from the same population.

Hypothesis testing aims to see the differences in students' problem-solving abilities based on computational thinking on data and diagram materials between the experimental class and the control class. Hypothesis testing uses an independent sample t-test, which is designed to compare the average pretest and posttest results of the two groups. The results of this test provide an overview of each learning model based on the data that has been obtained and analyzed as in Table 4 below.

Table 4. *Independent sample t-test*

		F	Sig.	t	df	Sig. (2-tailed)
Score	Equal variances assumed	0,712	0,403	2,431	44	0,019
	Equal variances not assumed			2,431	43,655	0,019

Based on the basis for decision making in this test, it states that if the significance value is less than 0.05, then (H_0) is rejected and (H_1) is accepted. Thus, the results of the hypothesis analysis show a difference in students' computational thinking-based mathematical problem-solving abilities in solving computational thinking-based problem-solving questions for statistical material: data and diagrams. This difference shows that the application of the Problem Based Learning (PBL) learning model is more effective than conventional learning methods.

DISCUSSION

The purpose of this study was to determine the differences in students' computational thinking-based mathematical problem-solving abilities in solving computational thinking-based problem-solving problems on statistics material: data and diagrams through the application of the PBL learning model. The sample consisted of two classes, VII-B as an experimental class that implemented the PBL model, and VII-C as a control class that applied conventional learning. Measurements were carried out through pretests and post-tests after four learning meetings.

In question 1, students were asked to solve problems by finding information based on data in the question, then presenting it in the form of a table. This question is also structured by containing four indicators of computational thinking, namely decomposition, pattern recognition, abstraction, and algorithms. This indicator requires students to be able to write down what information is known and asked and determine the pattern of the given question. The following Figure 1 shows question 1 of problem Solving Based on CT.

1. Pak Adi melakukan games tebak warna di kelas. Pak Adi telah menyiapkan box yang berisi 32 buah spidol berwarna-warni. Perhatikan gambar di bawah ini, lingkaran berwarna akan berbentuk segiempat ketika tebakannya benar dan akan tetap berbentuk lingkaran ketika tebakannya salah atau tidak dijawab. Berapa spidol yang berwarna merah jika spidol yang berwarna hijau sama dengan spidol yang berwarna ungu? Kemudian sajikan dalam bentuk tabel!

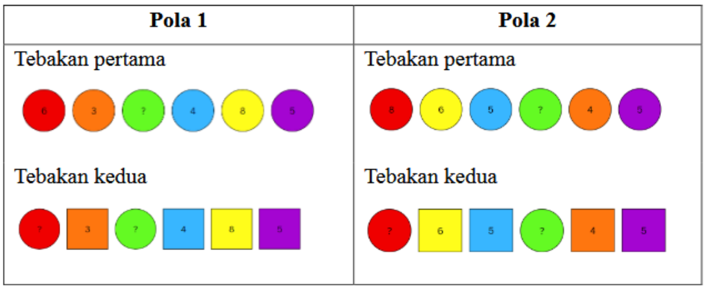
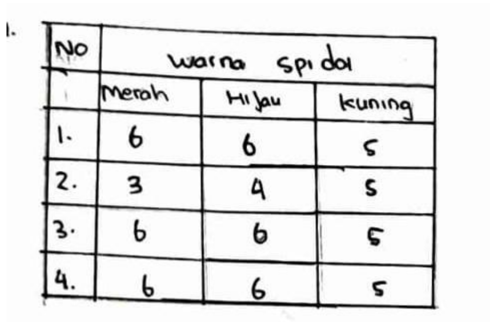


Figure 1. Question 1 CT-based Problem Solving



1.

No	warna spidol		
	Merah	Hijau	kuning
1.	6	6	5
2.	3	4	5
3.	6	6	5
4.	6	6	5

Figure 2. Results of Control Class Students' Answers for Question 1 Problem Solving Based on CT

Based on Figure 2, the results of the answer to question 1 by one of the control class students, the student did not write down what was known and asked in the question. The student also failed to recognize the pattern of the question, so he could not present the table correctly. This means that the student did not involve the decomposition and pattern recognition indicators.

1.

No	warna spidol	Jumlah spidol
1.	Merah	7
2.	Oren	3
3.	Hijau	5
4.	Biru	4
5.	kuning	8
6.	ungu	5
		32

Jadi hasil spidol berwarna merah adalah 32-25=7.

Figure 3. Results of Experimental Class Students' Answers for Question 1 Problem Solving Based on CT

Based on Figure 3, the results of the answer to question 1 by the experimental class student, the student also did not write down what information was known and asked from the question. However, the student was able to recognize the pattern in the question and find the appropriate answer. Then the student was also able to make an appropriate table, only slightly incomplete. From this student's answer, it is known that the student missed the decomposition indicator, but implemented the pattern recognition indicator. This student's answer also began to show quite good abstraction indicators.

Furthermore, in question 2, students were also asked to solve problems by finding information based on data in the question, then presenting it in the form of a pie chart. This question is structured by containing four computational thinking indicators, namely decomposition, pattern recognition, abstraction, and algorithms. This indicator requires students to be able to write down what information is known and asked and determine the pattern of the given question. After that, students are asked to present the data in a pie chart. The following Figure 4 shows question 2 problem solving based on computational thinking.

4. Di SMP An-Najah, seluruh siswa kelas VII diwajibkan untuk mengikuti ekstrakulikuler. Ada 4 ekstrakulikuler yang terdapat di SMP An-Najah. Diantaranya pramuka, al-banjari, tari, dan karate. Jika banyaknya seluruh siswa kelas VII di SMP An-Najah adalah 85 siswa, tentukan jumlah anak yang mengikuti ekstrakulikuler tari dan sajikan dalam bentuk diagram lingkaran!

Figure 4. Soal 2 Question 2 Problem Solving Based on CT

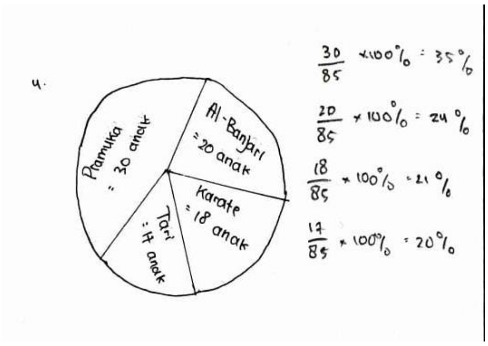


Figure 5. Results of Control Class Students' Answers for Question 2 Problem Solving Based on CT

Based on Figure 5, the results of the control class students' answers, students do not show decomposition indicators. Students immediately abstract according to the known pattern, namely with percentages. However, in presenting the pie chart, it is still not quite right, because they only write the number of children in the pie chart without using percentages.

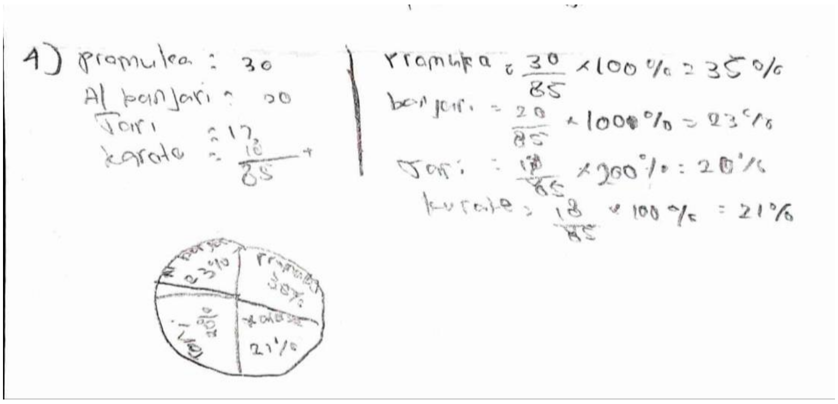


Figure 6. Results of Experimental Class Students' Answers for Question 2 Problem Solving Based on CT

Based on Figure 6, the results of the experimental class students' answers, students show decomposition indicators. Students also show indicators of pattern recognition and abstracting according to the known pattern, namely with percentages. Furthermore, in presenting the pie chart, it is also in accordance with the percentage of each criterion (extracurricular) of the question.

Before the hypothesis test was conducted, it was ensured that the data were normally distributed and homogeneous. The statistical test using the independent sample t-test produced a significance value of 0.019, which means that H_0 is rejected and H_1 is accepted. Thus, there is a significant difference between the learning outcomes of students taught with the PBL model and the conventional model (Ramadhani, 2019; Wardani, 2023).

The results of student scores are categorized into 3 categories, namely: low, medium, and high. This categorization is taken from the post-test score, this is because this stage has gone through a series of previous processes. In the control class, there were still many students in the low category with a percentage of more than 50%, which was 12 students. Then there were 5 students in the medium category, and 6 other students were in the high category. While in the experimental class there were 8 students in the low category, 3 students in the medium category, and the remaining 12 were in the high category.

The PBL model provides a more interactive learning experience, where students are invited to be actively involved in the process of solving real-world problems. In this study, students in the experimental class showed better abilities in the four main indicators of computational thinking in the problem-solving stage, namely decomposition, pattern recognition, abstraction, and algorithms. This finding is in line with research by Erniwati (2018), which states that students' problem-solving abilities increase when they learn directly through the problems they encounter. The use of the PBL model in learning can improve students' problem-solving abilities (Nisak, 2016).

In both control and experimental classes, an increase in grades was found, but the grades in the experimental class were higher. Learning activities in the control class were dominated by lectures and group assignments without actively involving students in the problem-solving process. In contrast, in the experimental class, PBL stages such as student orientation to the problem, group discussions, and presentation of results helped students develop critical thinking and computational thinking skills (Kresnadi et al., 2022; Rahma P et al., 2024).

As many as 74% of students in the experimental class were able to achieve the decomposition indicator, namely dividing large problems into smaller parts. In addition, 57% of students were able to recognize patterns in questions, 66% were able to abstract, and 65% were able to design algorithms as steps to solve problems. This success shows that the PBL model is effective in strengthening computational thinking skills, which are very important in solving complex problems (Kresnadi et al., 2022; Rahma P et al., 2024).

As many as 74% of students in the experimental class were able to achieve the decomposition indicator, namely dividing large problems into smaller parts. In addition, 57% of students were able to recognize patterns in problems, 66% were able to abstract, and 65% were able to design algorithms as steps to solve problems. This success shows that the PBL model is effective in strengthening computational thinking skills, which are very important in solving complex problems (Kresnadi et al., 2022; N. Christi & Rajiman, 2023).

However, some students are still in the low category in computational thinking skills, both in the control and experimental classes. This difficulty is often associated with a lack of strong mathematical foundations, thus hampering their ability to understand and apply problem-solving steps (Kamila et al., 2022). However, students in the high category in the experimental class showed greater engagement in the learning process, supported by the PBL approach that encourages active participation and contextual problem solving (Saad & Zainudin, 2022).

Based on the findings obtained in this study, it can be concluded that the implementation of the PBL model has a positive influence on students' ability to solve problems based on computational thinking. This learning approach not only successfully improves students' computational thinking-based problem-solving abilities, but also plays a role in developing critical and creative thinking skills that are very necessary to face challenges and problems in real life. Therefore, it is highly recommended for educators to more frequently implement learning strategies that focus on developing students' thinking skills, such as the PBL model, to support the mastery of 21st-century skills that are increasingly important in the modern world of education (Supiarmo, 2021; Fikriyah, 2022).

CONCLUSION

The results of this study indicate a difference in mathematical problem-solving abilities based on computational thinking between the experimental class and the control class. Students in the experimental class showed better abilities in solving mathematical problems based on computational thinking. The average pretest score in the control class that implemented the conventional model was 32, while the posttest score increased to 54. On the other hand, the experimental class that used the PBL model showed better results, with an average pretest of 49 and an average posttest reaching 63. These findings indicate that the PBL model is more effective in improving students' mathematical problem-solving abilities compared to the conventional learning model. It is recommended that teachers integrate the PBL model in learning to encourage students to be more active, schools provide training for teachers regarding the implementation of PBL, and other researchers develop similar research on different materials or educational levels to expand the scope of its benefits.

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