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PROBLEM-BASED LEARNING ASSISTED BY MICROSOFT EXCEL ON MATHEMATICAL COMPUTATIONAL THINKING

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Abstract

Mathematical computational thinking (CT) is an important thinking skill for supporting problem-solving in the current technology-based era. Still, mathematics learning activities at SMP Negeri 1 Kembaran have not fully leveraged it. This is due to limited ICT (Information and Communication Technology) facilities and teachers' lack of understanding of how to develop these abilities. This study aims to analyze whether Problem-Based Learning (PBL) assisted by Microsoft Excel affects the mathematical CT of seventh-grade students at SMP Negeri 1 Kembaran in data presentation. This study is a quasi-experimental post-test-only control design. Hypothesis testing was carried out using the Independent Sample t-Test assisted by SPSS 25. The study population was 226 seventh-grade students. The research sample was selected using a cluster-randomized sampling technique, with class VII-E as the experimental group and class VII-G as the control group. The results of the post-test mathematical CT showed that the average value (Mean) of the experimental group was 41.24, while the Mean of the control group was 14.74. The results of the hypothesis test using the Independent Sample t-Test with $\alpha = 0{,}05$ yielded t = 6.558 with df = 36.193; the value of (sig.(2-tailed))/2 ≤ 0.05, so it was concluded that PBL learning assisted by Microsoft Excel affected mathematical CT in the data presentation material. The results of this study contribute to the development of school-based learning activities that foster mathematical CT by leveraging readily accessible smartphones.

Keywords: Mathematical computational thinking, Microsoft Excel, Problem-Based Learning

INTRODUCTION

Today, human activities have shifted from being human-centered to technology-based (Fukuyama, 2018). Undoubtedly, technological knowledge and skills are fundamental elements in one's future career development (Rodríguez-martínez et al., 2019). This situation also occurs in Education. In mathematics learning, technology integration positively impacts student engagement, encourages the development of critical thinking and problem-solving skills, and significantly impacts motivation, attitudes, and academic achievement (Ali et al., 2023). Research shows that students tend to have positive feelings when learning mathematics through technology integration (Gqoli, 2024).

In mathematics learning, to enable students to integrate technology into mathematical content and learning and to develop critical thinking skills and achieve meaningful learning, they must master various skills, particularly CT (Subramaniam et al., 2022). With CT, students can solve more complex mathematical problems using appropriate tools and methods (Mohaghegh & McCauley, 2016), engage in problem-solving processes, and create modifiable artifacts (Shin et al., 2021). CT has evolved and become an essential skill in mathematics learning (Irawan et al., 2024), not only for mathematicians but also for everyone (Li et al., 2020). In addition to reading, writing, and arithmetic, CT serves as a foundation for students' analytical thinking (Weintrop et al., 2015).

CT is defined as a method or approach for solving problems, designing systems, and understanding human behavior that incorporates fundamental computer concepts (Mohaghegh & McCauley, 2016). CT can be envisioned as a thought process in which problems are represented so that solutions can be evaluated using information-processing techniques with a logical, systematic, and algorithmic approach (Mohaghegh & McC. CT can be described as the ability to think logically, algorithmically, efficiently, and innovatively (Mohaghegh & Mccauley, 2016). Indicators of CT ability include collecting, creating, manipulating, analyzing, and visualizing data (Weintrop et al., 2015). n this study, CT is defined as: 1) Abstraction, where students can simplify information by focusing on important information and identifying existing problems; 2) Data Analysis, where students can collect, store, and analyze data to solve problems; 3) Algorithmic Thinking, where students can create sequential steps to solve problems using computational tools; and 4) Data Visualization, where students can visualize data in tables or graphs and draw conclusions or generalize the information.

Although CT plays a crucial role in mathematics learning today, learning activities that develop CT have not been optimally implemented in Indonesia (Azmi dan Ummah, 2021). This is demonstrated by the fact that current mathematics learning activities often use less student-centered methods that only train students to solve problems by applying memorized formulas. As a result, the learning process does not develop students' CT, and their CT abilities in mathematics are relatively low (Supiarmo, et al., 2021).

SMP Negeri 1 Kembaran, a school in Banyumas Regency, Central Java, also experienced a similar situation. Interviews with mathematics teachers at the school revealed that they had not fully leveraged ICT (Information and Communication Technology) in mathematics lessons to develop CT. This is one reason why students find it difficult to present data in graphs with the same scale or the correct proportions when learning about data presentation. SMP Negeri 1 Kembaran was chosen as the research site because the school's mathematics lessons have not yet developed CT due to limited ICT facilities and teachers' lack of understanding of how to develop this skill.

One learning model suspected of influencing the development of CT is Problem-Based Learning (PBL)(Cui et al., 2023). PBL is a learning model that begins with the presentation of a problem, which can be a real-world (authentic), unstructured (ill-structured), or open-ended problem, as a stimulus for students to find solutions (Arviana & Parma, 2018; Mustaffa et al., 2016). The PBL learning process is student-centered, focusing on real-life problems students face (Jonasen et al., 2019; Mustaffa et al., 2016). Research shows that PBL implementation impacts CT and encourages students to become good problem solvers (Hapizah et al., 2024). Furthermore, PBL is a widely used learning model for teachers to develop CT across various subjects (Hsu et al., 2018). PBL, built on real-life problems, is capable of developing CT effectively (Aryan et al., 2023).

Various studies indicate that Microsoft Excel can support the development of computational thinking through data analysis, formula use, and systematic problem-solving (Taufik & Susanti, 2024; Yuliana et al., 2026); meanwhile, the Problem-Based Learning (PBL) model has also proven effective in enhancing computational thinking through the resolution of authentic problems (Aryan et al., 2023). However, these two approaches have generally been studied in isolation. To date, research integrating Microsoft Excel into the PBL framework to enhance computational thinking skills remains very limited. Therefore, this study is crucial for addressing this gap and providing empirical evidence regarding the effectiveness of integrating Microsoft Excel into problem-based learning to develop students' computational thinking skills.

METHOD

The research method used was a quasi-experimental one, as the researcher could not control all factors influencing students' CT. The research design used a post-test-only control design, meaning the same post-test questions were given to the experimental group (classes implementing PBL with Microsoft Excel) and the control group (classes using conventional learning) after the treatment was completed.

The study population consisted of all seventh-grade students at SMP Negeri 1 Kembaran. The sample in this study comprised 62 seventh-grade students: 31 from class VII-E (experimental group) and 31 from class VII-G (control group).

The post-test questions designed to measure CT are based on the specifications in Table 1.
An example of a post-test question to measure CT is shown in Figure 1.

Table 1. Post-test Questions Specification

Indicator	Number
Abstraction a. Simplifying information about the issues read by focusing on key details b. Identifying the problems that arise	 1a 2a
Analyzing data a. Collecting the data needed for problem-solving. b. Storing the data in a suitable computing tool. c. Analyzing the data to identify the most appropriate data visualization.	 1b 2b, 3a 1c
Algorithmic thinking Capable of creating sequential steps for problem-solving using computational tools.	2c
Visualizing data a. Visualizing data in the form of graphs or tables using computational tools. b. Drawing conclusions or generalizations to convey information to others.	 3b 2d

The following is data on the sales volume of Brand X motorcycles in several major cities in Indonesia over the past two years.

City	High Sales Volume of Motorcycle X
Jakarta	850
Surabaya	600
Medan	874
Semarang	596
Bandung	468
Denpasar	580
Balikpapan	375

The motorcycle entrepreneur wants to compare motorcycle sales across these major cities and plans to increase promotional efforts in the three cities with the lowest sales figures.

a. Select a suitable chart to present the sales data for motorcycle brand X, and explain your reason for choosing that chart. **(Abstraction)**
b. Create the chosen chart in Microsoft Excel on a mobile phone using the data provided above. **(Analyzing Data)**
c. What steps did you take to create the chart? (**Algorithmic Thinking)**
d. Based on the chart you created, in which cities should the entrepreneur for motorcycle brand X increase promotional efforts? **(Visualizing Data)**

Figure 1. Post-test question to measure CT

Each answer is evaluated using a holistic scoring rubric, with scores assigned as follows: 3 for a completely correct answer, 2 for an answer with minor errors, 1 for an answer with major errors, and 0 for a completely incorrect answer.

The sample was drawn using a cluster-random sampling technique, in which two classes were randomly selected from the seventh-grade population. According to the 7th-grade mathematics teacher, classes at SMP Negeri 1 Kembaran are distributed evenly, with no special classes based on ability.

The data collection technique used descriptive CT test questions. The trial was conducted in class VII F with 29 students. The validity of the test items was tested using the Pearson Product-Moment Correlation test using SPSS 25, with a significance level of $\alpha = 0.05$. The items were considered valid if the sig. (2-tailed) $< \alpha$. The results of the Pearson product-moment correlation test in Table 2 show that all test items are valid for measuring students' CT, because the significance value is < 0.05.

Table 2. Item Validity Results

Item	Sig. (2-tailed)	Decision
1a	0,005	Valid
1b	0,001	Valid
1c	0,001	Valid
2a	0,000	Valid
2b	0,000	Valid
2c	0,001	Valid
2d	0,000	Valid
3a	0,016	Valid
3b	0,001	Valid

Reliability testing was conducted with Cronbach's Alpha in SPSS 25. Using a significance level of $\alpha = 0{,}05$, the questions are considered reliable if $r_i > 0{,}6$ (Farida & Musyarofah, 2021). Based on the calculation results, a Cronbach's Alpha coefficient of 0.654 was obtained; therefore, the test item is reliable.

Post-test data analysis techniques include prerequisite tests (normality and homogeneity tests) and hypothesis testing. Normality testing is performed using the Shapiro-Wilk test with a significance level of 0.05; data are normally distributed if the p-value is. value is $> \alpha$. Meanwhile, the homogeneity test is used to determine whether the data set being tested has the same characteristics (Sugiyono, 2017). Testing was carried out using Levene's test, with a significance level of $\alpha = 0{,}05$, the data is homogeneous if the sig. value $> \alpha$.

Next, a hypothesis test was conducted, with the null hypothesis (H_0): the average CT of students on data presentation material following Microsoft Excel-assisted PBL (μ_1) is equal to or less than the average CT of students following the conventional learning model (μ_2). In other words, there is no effect of Microsoft Excel-assisted PBL on student CT.

In this study, the hypothesis test was conducted using the parametric statistical method of the Independent Sample t-Test with a significance level (α) of 0.05. H_0 is rejected if the value (sig. (2-tailed))/2 $\leq \alpha$ by looking at the sig. (2-tailed) value in the Equal variances assumed row (if it meets the normality and homogeneity prerequisite tests) and in the Equal variances not assumed row (if it meets normality and is not homogeneous).

RESULTS AND DISCUSSION

Descriptive statistical data on the post-test scores of the experimental group and the control group are presented in Table 3.

Table 3. Descriptive Statistics Post-test Score

	N	Minimum	Maximum	Mean	Std. Deviation
Score_CT_Experiment	31	10.00	98.30	41.2419	21.41320
Score_CT_Control	31	.00	33.30	14.7387	6.91673

Table 3 shows that the minimum, maximum, and average scores of the experimental class were higher than those of the control class. The difference in the average score between the experimental and control classes was quite large, at 26.5032. Based on these results, it can be assumed that the experimental class performed better than the control class. Meanwhile, the difference in the standard deviation between the experimental and control classes was quite large, at 14.49647. With such a large difference, it can be assumed that the two classes are not homogeneous. Both the average and the standard deviation differences will be tested using hypothesis testing.

The prerequisite analysis test begins with the Shapiro-Wilk normality test, and the results are in Table 4. Based on Table 4, both the experimental and control groups are normally distributed, as the p-values are greater than 0.05.

Table 4. Post-test Score Normality Test Results

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Group	Statistic	df	Sig.	Statistic	df	Sig.
Skor CT	Experimen	.165	31	.032	.946	31	.121
	Control	.173	31	.019	.936	31	.063
a. Lilliefors Significance Correction							

The results of the homogeneity test using Lavene's test in Table 5 show that the CT scores of the experimental and control groups are heterogeneous, as the significance value based on the Mean is 0.000 < 0.05.

Table 5. Homogeneity Test of Post-test Scores

		Levene Statistic	df1	df2	Sig.
Nilai Mathematical CT	Based on Mean	22.536	1	60	.000
	Based on Median	15.234	1	60	.000
	Based on Median and with adjusted df	15.234	1	35.564	.000
	Based on trimmed Mean	20.399	1	60	.000

The analysis of CT post-test scores on the data presentation material for the experimental and control groups shows that the data are normally distributed but not homogeneous, so the decision-making in the hypothesis test is based on the Independent-Samples t-Test under the Equal variances not assumed. The results of the hypothesis test in Table 6 show that the Sig. (2-tailed) value of the Equal variances not assumed row is 0.000, where the value (sig. (2-tailed)) / 2 ≤ 0.05. This means that H_0 is rejected, or in other words, the average CT score of students on the data presentation material following PBL assisted by Microsoft Excel is more than the average CT score of students on the data presentation material following the conventional learning model. This means that PBL assisted by Microsoft Excel has an effect on students' CT abilities.

Table 6. Hypothesis Testing Using Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Nilai Mathematical CT	Equal variances assumed	22.536	.000	6.558	60	.000	26.5032	4.0416	18.4189	34.5876
	Equal variances not assumed.			6.558	36.193	.000	26.5032	4.0416	18.3080	34.6984

Microsoft Excel-assisted PBL learning is superior to conventional learning in mathematical CT for data presentation. This is because Microsoft Excel-assisted PBL provides ample opportunities for students to develop their conceptual understanding. A strong understanding of concepts enables students to identify patterns, analyze relationships, and develop systematic solutions, thereby fostering computational thinking skillsv(Ukkonen et al., 2025).

Microsoft Excel-assisted PBL is implemented in five steps. In the first step, the teacher orients students to the problem. The teacher divides students into groups, distributes worksheets to each group, and then presents a contextual problem that each group needs to investigate. By providing contextual problems and getting students used to investigating them, they begin to develop abstraction skills (Lehmann, 2025). In this process, students begin to identify problems and simplify information about the issues read by focusing on key details.

Meanwhile, students, together with their groups, examine and understand the contextual problem explained by the teacher and clarified in the student worksheet. Then, they open Microsoft Excel on a group member's smartphone. This activity helps students abstract the problem.

The second step is organizing students for learning. In this step, the teacher directs each group to assign tasks to its members (leader, Microsoft Excel operator, secretary, and others). Then, students discuss and plan solutions to the problem. The activities of discussing and planning solutions are crucial steps in identifying and resolving problems (Manurung & Pappachan, 2025). This activity also helps students abstract the problem.

The third step is guiding individual and group investigations. In this step, each group conducts investigations to solve the contextual problem. The activities carried out by students in their groups during this investigation included: understanding the commands in the Microsoft Excel display on their smartphones, identifying data related to the problem, inputting the data into Microsoft Excel and then presenting it in a table or graph (line chart, bar chart, pie chart) according to the appropriate steps for presenting data with the application provided in the Student Worksheet and drawing conclusions from the table or graph. During the investigation, students developed a thought process to understand the material through group discussions and online searches for reference sources (Manurung & Pappachan, 2025). The teacher monitored and guided each group if they encountered difficulties. Activities in this step supported students in data analysis, algorithmic thinking, and data visualization.

The fourth step was developing and presenting their work. In this step, the teacher directed each group to complete the student worksheets and to send the tables or graphs they had created to the teacher via WhatsApp. Then each group followed the teacher's instructions. This activity helped students visualize the data (Ukkonen et al., 2025). The final step was analyzing and evaluating the problem-solving process. In this step, the teacher instructed one group to present the results of their discussion related to contextual problem-solving to the class. One group then presented their findings, and the other groups appraised the results of the group's discussion. Next, the teacher, through questions and answers with the students, evaluated the presenting group's problem-solving process to determine whether it was appropriate. Furthermore, the teacher summarized the material together with the students. This activity also supported students in data visualization (Lehmann, 2025).

PBL learning, supported by Microsoft Excel on smartphones, guided students to actively participate in learning, collaborate, independently build conceptual understanding of the material based on contextual problems, and trained them to integrate mathematical CT in solving contextual problems in data presentation materials. Post-test results showed that most students who participated in the learning achieved three indicators of mathematical CT: abstraction, data analysis, and data visualization. Meanwhile, only a few students achieved algorithmic thinking.

In conventional learning models, learning activities are teacher-centered, beginning with the teacher explaining the material, then providing examples of data presentations in tables and graphs, and explaining the steps for presenting data in tables or graphs. While the teacher explained the material, students observed and understood the teacher's explanations. Then, they completed independent practice questions to practice presenting data in tables or graphs by hand. Post-test results showed that most students who participated in the learning achieved two indicators of mathematical CT, namely abstraction and data analysis. Meanwhile, only a few students achieved data visualization, and none achieved algorithmic thinking.

Compared to conventional learning models, PBL learning with Microsoft Excel significantly developed mathematical thinking skills. The use of Microsoft Excel on smartphones in the experimental group's PBL learning activities enabled students to actively solve mathematical problems and practice algorithmic thinking and data visualization (Yaghoobi et alm 2025). This contrasted with the learning activities in the control group, which used a conventional learning model without smartphones, leading to passive learning and less practice in algorithmic thinking and data visualization. This also suggests that the use of learning media in mathematics can support the development of students' mathematical abilities.

Although the results showed that the average score (Mean) of students participating in PBL learning with Microsoft Excel was higher than the average score (Mean) of students participating in conventional learning, the mean score of students participating in PBL learning with Microsoft Excel did not reach the Minimum Competency (70). This may be because mathematical thinking, particularly in data presentation, was a new topic for seventh-grade students at SMP Negeri 1 Kembaran. During this learning period, students were new to using Microsoft Excel on smartphones to present data in tables and graphs. In addition, allocating only 50 minutes (2 lesson hours) for learning creates challenges for students in understanding the material.

CONCLUSION

Based on the results and discussion, it can be concluded that Problem-Based Learning (PBL) assisted by Microsoft Excel has an effect on the Mathematical Computational Thinking (CT) of seventh-grade students at SMP Negeri 1 Kembaran in data presentation. The hope of the results of this study is that PBL assisted by Microsoft Excel can be used as an alternative learning model for mathematics teachers at the junior high school level in developing students' mathematical CT on data presentation material and there needs to be further research related to the development of mathematical CT with PBL assisted by more advanced software than Microsoft Excel, for example Tableau or Power BI.

This study has several limitations that should be considered when interpreting the findings. First, the study employed a quasi-experimental post-test-only control group design, which did not allow comparisons of students' initial computational thinking abilities before the intervention. Second, the research involved only 62 seventh-grade students from a single junior high school, limiting the generalizability of the findings to broader educational contexts. Finally, the study focused solely on students' learning outcomes through post-test scores and did not investigate the learning process, students' perceptions, or long-term retention of computational thinking skills. Therefore, future studies are recommended to employ a pretest-posttest experimental design, involve larger and more diverse samples, implement longer intervention periods, and explore the use of more advanced data analysis software, such as Tableau or Power BI, to further enhance students' computational thinking skills.

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