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Enhancing Students' Mathematical Literacy Skills through Contextual Teaching and Learning (CTL) and Problem Based Learning (PBL) Approaches

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ABSTRACT

The results of the PISA survey conducted by the OECD indicate that the mathematical literacy skills of Indonesian students remain low. Ranking 66th out of 81 countries further demonstrates that Indonesia is still lagging behind other nations. This study aims to improve students' mathematical literacy skills through two alternative learning approaches: Contextual Teaching and Learning (CTL) and Problem-Based Learning (PBL). The research employed a quasi-experimental design with a pretest-posttest approach to collect data. The population was drawn from a junior high school in Yogyakarta, with a sample consisting of two eighth-grade classes. The research instrument was a mathematical literacy test based on PISA-type questions. The findings revealed that both CTL and PBL approaches were effective in enhancing students' mathematical literacy skills. However, further comparative effectiveness analysis showed that the CTL approach was more effective than PBL. This research is expected to serve as an alternative reference for educators and future researchers in efforts to enhance students' mathematical literacy.

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INTRODUCTION

The quality of education in a country is undoubtedly a concern for its government, including Indonesia. One way to measure educational quality is by looking at learning outcomes in schools. These outcomes are closely tied to students as the primary subjects of learning. In Indonesia, student learning outcomes can be assessed through exams administered by individual schools. However, the educational quality of a country today can also be evaluated through the OECD's PISA survey. The PISA survey is conducted every three years by the OECD to assess the reading, mathematical, and scientific literacy of 15-year-old students. Indonesia has participated in PISA eight times in 2000, 2003, 2006, 2009, 2012, 2015, 2018, and 2022. PISA survey results on students' mathematical literacy can be seen in Table 1.

Tabel 1. Score Students' Mathematical Literacy

Year	Score	Rank	Participants
2000	360	39	41
2003	391	38	40
2006	379	50	57
2009	371	60	65
2012	375	64	65
2015	386	63	70
2018	379	69	79
2022	366	66	81

The trend in PISA survey results on students' mathematical literacy can be seen in The Figure 1.

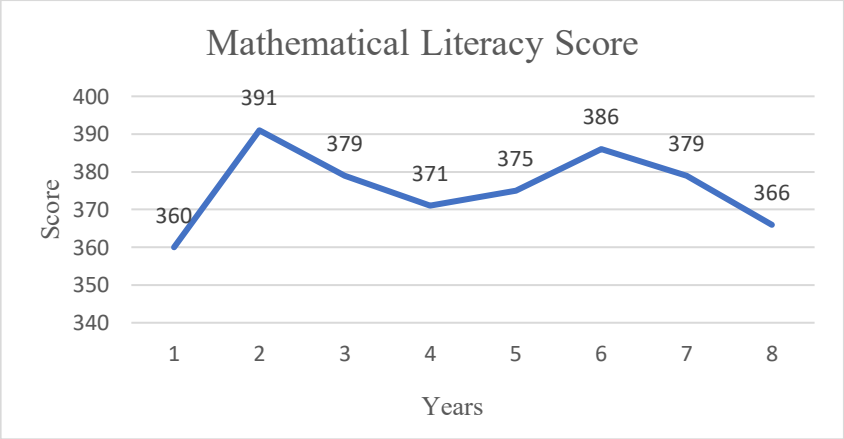

Figure 1. Trend of Score Mathematical Literacy

Figure 1 shows that the trend in Indonesian students' PISA scores fluctuates across eight surveys. However, the last three surveys show a decline in mathematical literacy scores. This means further research is needed to improve students' mathematical literacy scores, even though the 2022 rankings showed an improvement from 2018.

The low PISA scores and rankings of Indonesian students highlight a pressing issue that needs immediate attention. Since the implementation of the Merdeka Curriculum, the government has introduced the Computer-Based National Assessment (ANBK), which includes the Minimum Competency Assessment (AKM) to evaluate students' reading and mathematical literacy (numeracy). This assessment is modeled after the PISA survey, both in terms of question types and the skills tested. Thus, the AKM serves as the government's response to the low literacy skills reflected in PISA scores. Therefore, at the school level, learning methods that enhance students' literacy skills must be prioritized. Mathematical literacy refers to a person’s capacity to recognize and

comprehend the role of mathematics, to make well-grounded mathematical decisions, and to apply mathematics in ways that address present and future needs as responsible, thoughtful, and engaged members of society (Zahrah, 2024). Mathematical literacy goes beyond simply carrying out mathematical procedures. It equips students with the ability to make estimations, analyze data, solve problems, and justify their reasoning in a variety of contexts involving numbers, graphs, and geometric concepts (Putri & Fakhriyana, 2023). This form of literacy integrates logical thinking with the application of mathematical ideas, methods, facts, and tools to describe, interpret, and anticipate real-world events (Hardianti et al., 2025).

Research indicates that several factors influence students' mathematical literacy, including internal factors (prior knowledge, self-efficacy, and interest) and external factors (teaching models, learning materials, and environment) (Sulfayanti, 2023). Other studies show that teaching models such as PBL (Problem-Based Learning), PjBL (Project-Based Learning), Discovery Learning, Metacognitive Guidance, and Blended Learning exerts a greater influence on students' mathematical literacy than traditional instructional approaches (Amelia et al., 2022). Thus, teaching approaches and models must continue to evolve to improve students' mathematical literacy.

The mathematical literacy questions in the PISA survey are contextual and problem-solving. In mathematical literacy content, the questions presented are closely related to real-life issues. Therefore, a relevant learning approach is needed to train students to solve problems in real life. Since PISA assesses mathematical literacy through real-world problem-solving tasks, the learning approach should connect mathematics to everyday life. A suitable approach for linking mathematics to daily contexts is Contextual Teaching and Learning (CTL), while Problem-Based Learning (PBL) is highly relevant for developing problem-solving skills. CTL is a teaching approach that emphasizes student engagement and connects learning material to real-life situations (Ester et al., 2023). Thus, CTL centers learning on students as the primary subjects of education. CTL is a learning system that aligns with brain functioning to construct meaningful patterns by connecting academic content with learners' real-life contexts (Surdin, 2018). CTL also enables students to apply mathematics in daily life (Junianto & Wutsqa, 2019). This approach emphasizes active student engagement in the learning process (Sadilah & Winarto, 2021). The CTL approach used in this research refers to the five basic CTL principles, namely REACT (Relating, Experiencing, Applying, Cooperating, and Transferring). REACT has been proven to improve student learning outcomes, so it is hoped that it can enhance students' mathematical literacy (Hakim, 2017).

The Problem-Based Learning (PBL) approach can also serve as an alternative to enhance students' mathematical literacy. PBL is a learning method focused on solving

real-world problems (Junianto & Wijaya, 2019). It offers learning and growth opportunities by using real-life problems that students encounter, aiming to enhance their higher-order thinking abilities (Widyastuti & Airlanda, 2021). Research indicates that PBL effectively facilitates active student participation and improves learning outcomes (Khakim et al., 2022). Additionally, PBL aims to increase students' interest in mathematics and enhance their academic performance, thereby sharpening critical thinking and problem-solving skills (Ni'mah et al., 2024).

CTL and PBL approaches can serve as effective alternatives for enhancing students' mathematical literacy. Research evidence supports this claim, demonstrating that: 1) PBL significantly improves critical thinking skills (Ni'mah et al., 2024);2) PBL effectively enhances students' numeracy abilities (Wibowo et al., 2022); 3) CTL contributes to improved academic achievement (Artini, 2022). CTL strengthens students' mathematical problem-solving skills (Muslihah & Suryaningrat, 2021). The problem-solving skills developed through PBL directly influence students' mathematical literacy (Samosir, 2022). These findings collectively suggest that both CTL and PBL offer robust pedagogical approaches for advancing mathematical literacy by fostering critical thinking, problem-solving capabilities, and real-world application of mathematical concepts.

Theories about the CTL and PBL approaches are supported by several previous studies, suggesting that both learning approaches could be alternatives for improving students' mathematical literacy. Furthermore, no research has specifically compared the two approaches in improving students' mathematical literacy. Therefore, this study aimed to determine the effectiveness of CTL and PBL in improving students' mathematical literacy. This research is anticipated to serve as a valuable reference for future researchers and educators in implementing either CTL or PBL approaches. By adopting these evidence-based teaching methods, improvements in students' mathematical literacy can be achieved, ultimately contributing to enhanced PISA scores and Indonesia's ranking in subsequent OECD assessments.

METHOD

The population of this study consisted of all eighth-grade students at one of the junior high schools in Yogyakarta, with the research sample comprising two classes assigned as Experimental Class 1 and Experimental Class 2. The method used was a quasi-experiment with a quantitative approach. Experimental Class 1 was treated with the CTL (Contextual Teaching and Learning) approach, while Experimental Class 2 used the PBL (Problem-Based Learning) approach. The two classes were selected based on their similar initial abilities, as suggested by the classroom teacher. Research data were

obtained from pretest and posttest scores. The pretest and posttest instruments contained mathematics questions based on PISA-type problems. The instruments were tested for validity and reliability before being used for data collection. Instrument validity testing consists of 2 types, namely content validity testing by experts and construct validity with empirical trials, while reliability testing with Chronbach's alpha. Pretest data were first tested for assumptions, including normality and homogeneity tests, followed by a mean difference test of initial ability as confirmation of the classroom teacher's suggestion. Once the initial abilities of both classes were confirmed to be equal, the effectiveness of the learning approaches was tested. If both approaches proved effective, a comparative test was conducted to assess the effectiveness of CTL versus PBL. Below is the table of the research design.

Table 2. Research Design

O_1	X	O_2
O_3	X	O_4

Information:
O_1 : *Experimental class 1 Pre-test*
O_3 : *Experimental class 2 Pre-test*
X : *Treatment*
O_2 : *Experimental class 1 Post-test*
O_4 : *Experimental class 2 Post-test*

The effectiveness of each learning approach on mathematical literacy was examined through data analysis with a one-sample t-test conducted in SPSS. An independent sample t-test was administered as a follow-up analysis to compare the effectiveness of the CTL and PBL approaches by examining the mean scores of the two experimental groups. Meanwhile, the one-sample t-test (analyzed with SPSS) assessed the effectiveness of each instructional approach in improving mathematical literacy by comparing posttest results against a predetermined benchmark.

RESULTS AND DISCUSSION

The pretest and posttest data on students' mathematical literacy obtained in this study are presented in the following table.

Table 3. Mathematical Literacy Data

Description	Experimental Class 1		Experimental Class 2	
	Pre-test	Post-test	Pre-test	Post-test
Avarage	57,17	86,21	51,53	80,20
Minimum Score	0	0	0	0
Maximum Score	100	100	100	100

After obtaining the data, normality and homogeneity tests were conducted using SPSS software to verify the parametric test assumptions.

Table 4. Test of Data Normality

Test	Respondents	Mean	Sig. (2-tailed)
Pretest Experimental Class 1	34	57,17	0,20
Pretest Experimental Class 2	34	51,53	0,10
Posttest Experimental Class 1	34	86,21	0,15
Posttest Experimental Class 2	34	80,20	0,20

Table 3 indicates that the significance values for both pretest and posttest scores exceed the alpha level ($\alpha = 0{,}05$), confirming normal distribution in both experimental classes. The analysis proceeded with homogeneity of variance testing.

Table 5. Test for Variance Homogeneity

Levene Statistic	Sig.
3,681	0,058

Findings from analysis revealed students' mathematical literacy data from both classes exhibited homogeneous variance (significance value $> \alpha = 0{,}05$). After confirming that the data met both normality and homogeneity assumptions, the analysis proceeded with testing the mean difference in pretest scores between the two classes.

Table 6. Results of Testing Mean Equality

Score	Df	Difference of Means	Sig. (2-tailed)
Pretest Scores	66	-1,44	0,655

As presented in Table 6, The significance value exceeded the alpha level ($p > 0.05$), suggesting that there is no statistically significant difference in the mean scores of the two classes. This analytical result confirms the teacher's preliminary assessment that both classes had relatively equivalent baseline capabilities.

The next phase of analysis examined how effective CTL and PBL approaches are in enhancing students' mathematical literacy. The following results present the effectiveness tests conducted using SPSS.

Table 7. Output of the One-Sample t-test

Posttest Score	Df	Mean Difference	Sig (2-tailed)
Experimental Class 1	66	13,20	0,000
Experimental Class 2	66	6,11	0,022

Table 7 shows that the significance values for both experimental classes were below the alpha threshold ($p < 0.05$), leading to the conclusion that students' mathematical literacy was successfully enhanced through the use of CTL and PBL approaches.

The final analytical stage of this study compared the relative effectiveness of these instructional approaches. An independent samples t-test was carried out on the posttest scores to determine which approach (CTL or PBL) demonstrated significantly greater improvement in mathematical literacy.

Table 8. T-test for Independent Samples Result

Posttest Score	**t**	**Df**	**Mean Difference**	**Sig (2-tailed)**
t-test for Equality of Means	2,11	66	7,08	0,0195

Table 8 reveals that the significance value is below the alpha threshold ($p < 0.05$), indicating that Experimental Class 1 (taught using the CTL approach) demonstrated statistically greater improvement in students' mathematical literacy compared to the PBL approach.

The analysis demonstrates that both CTL and PBL approaches effectively enhanced students' mathematical literacy. Initial pretest data met all required assumptions: Normality and homogeneity assumptions were satisfied for both classes. An independent samples t-test confirmed equivalent baseline capabilities ($p > 0.05$). Pretest means showed comparable starting points: Experimental Class 1 (CTL): M = 57.17; Experimental Class 2 (PBL): M = 51.53.

The impact of the Contextual Teaching and Learning (CTL) approach on improving mathematical literacy was evaluated based on posttest results. The effectiveness threshold was established based on the school's Learning Objective Achievement Standard of 75. Statistical analysis revealed that the mean posttest score (86.21) significantly surpassed the institutional benchmark of 75. The positive N-gain score (0.36) indicates meaningful improvement in mathematical literacy, while the posttest average (86.21) demonstrates that the CTL approach successfully met and surpassed the institution's proficiency standards. CTL approach significantly enhanced students' mathematical literacy through three key mechanisms: 1) Real-World Relevance: by explicitly connecting mathematical concepts to daily life applications; 2) Motivational Enhancement: classroom observations revealed increased student engagement, consistent with expectancy-value theory; 3) Problem-Solving Transfer: students demonstrated improved ability to apply mathematical reasoning to authentic problems. These findings align conclusively with existing empirical evidence demonstrating CTL's efficacy in enhancing mathematical problem-solving (Muslihah & Suryaningrat, 2021).

The data analysis confirms that the REACT framework (Relating, Experiencing, Applying, Cooperating, and Transferring) implemented in our CTL approach significantly enhanced students' mathematical literacy. This strategy makes students enthusiastic and excited about learning because they engage in collaboration, group discussions, and presentations of their learning outcomes. Other similar studies have also shown that the CTL approach has been shown to be effective in enhancing students' academic achievement (Artini, 2022).

In Experimental Class 1, student interaction is more extensive due to the Cooperating stage. At this stage, students are quite enthusiastic about collaborating and discussing if they don't understand a concept they've learned. These discussions and explanations from peers help students gain deeper understanding because they don't hesitate to ask their peers. Unlike in Experimental Class 2, students are faced with problems or issues in everyday life that require solutions. Students with strong analytical skills will be able to solve these problems. However, students with weak analytical skills tend to be confused because they aren't given the concept at the beginning of the lesson. Students also tend to solve problems independently. Furthermore, PBL requires students to solve problems without a concept at the beginning of the lesson. This is very beneficial for students with strong analytical and critical thinking skills because it can sharpen their abilities. Conversely, students with low analytical skills will stall at a certain stage when understanding the problem they face.

In Experimental Class 2, PBL approach was likewise effective in enhancing students' mathematical literacy. This is evident from the average N-gain score, which showed a positive result of 0.59, with an average post-test score of 80.20. The PBL approach is based on solving real-life problems. When compared to the CTL class, an interesting finding is that the N-gain score for PBL was higher than the N-gain score for the CTL class. This could be due to several factors, including a lack of seriousness in the pretest in the PBL class, resulting in lower scores. Furthermore, in the posttest, students were more challenged because they were faced with problems during the learning process and learned the right solutions after being confronted with them. Learning that focuses on problem-solving also trains students' mathematical literacy skills, as they must first understand the context of the problem and then determine the appropriate solution. This is consistent with previous research showing that PBL is effective in enhancing students' numeracy skills (Wibowo et al., 2022). Similarly, Widyastuti & Airlanda (2021) found that the PBL model can improve students' mathematical problem-solving abilities.

The post-test results in Experimental Class 1 were higher than those in Experimental Class 2, with a significant difference of 6.01 points. This finding is consistent with the effectiveness analysis, which indicates that the CTL approach is more

effective in improving students' mathematical literacy compared to the PBL approach. CTL is more effective because it trains students to first understand mathematical concepts before applying them to real-life situations. The REACT strategy used in CTL fosters students' enthusiasm and motivation for learning. Through this strategy, students learn the concrete applications of mathematics in daily life, not just abstract theories. This also suggests that students need to comprehend the fundamental concepts of mathematics before they can fully appreciate its usefulness and relevance in everyday contexts.

CONCLUSION

Based on the research findings and analysis, students' mathematical literacy skills improved through the implementation of the CTL and PBL approaches. Both approaches were equally effective in improving students' mathematical literacy. Based on the posttest results and comparison of effectiveness, it can be concluded that the CTL approach was more effective and had a significant impact on improving students' mathematical literacy skills. However, the score difference was not significant, indicating that both CTL and PBL are suitable approaches for improving mathematical literacy. Interestingly, the N-gain score in the PBL class was higher than in the CTL class, as discussed previously. The results of this study can also serve as an alternative for teachers, schools, and policymakers in implementing learning approaches. Although this research was limited to one school and has not been expanded, it is hoped that the implementation of CTL and PBL will improve students' mathematical literacy skills and have a positive impact on PISA results more broadly. This study also offers opportunities for further research, such as analyzing N-gain scores, comparing them with other approaches, or conducting further research.

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