



The Effectiveness of The Challenge-Based Learning (CBL) Model on Students' Mathematical Literacy Skills

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Abstract

Mathematical literacy skills are essential for students to practice problem-solving in everyday life. However, the mathematical literacy skills of students at SMP Negeri 5 Magelang are still relatively low, with an initial average score of 38.4. Therefore, solutions are needed to improve students' mathematical literacy skills. One such solution is implementing the Challenge Based Learning (CBL) model. This research aims to analyse the completeness of mathematical literacy skills of students who follow the learning process using the CBL model, analyse the completeness of mathematical literacy skills of students who follow the learning process using the direct instruction model, & compare the effectiveness of the CBL model with the direct instruction model in improving students' mathematical literacy skills. The research method used is a quasi-experimental design with a pre-test, post-test, and nonequivalent control group. The sampling technique used is cluster random sampling, with Class IX D consisting of 30 students as the experimental class and Class IX E consisting of 29 students as the control class. Data analysis results show that students' mathematical literacy skills, both with the CBL model and the direct instruction model, reach completeness. Additionally, the Challenge Based Learning (CBL) model is more effective than the direct instruction model in enhancing students' mathematical literacy skills.

Keywords: Challenge Based Learning, Direct Instruction, Mathematical Literacy Skills

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INTRODUCTION

Mathematics is a branch of science that plays a crucial role in human life and serves as a foundation for other fields of study (Yensy, 2020). In the era of Society 5.0, mathematics plays a crucial role in technological development and innovation, helping to shape graduates with improved mathematical skills (Daimah & Suparni, 2023). However, in reality, mathematics becomes a subject feared in school learning because students consider mathematics as a complicated subject, resulting in very low student interest in mathematics (Sriwahyuni, Rahmatudin, & Hidayat, 2019).

Mathematics not only demands students to be good at counting but also to have the ability to reason logically and critically when solving problems (Hasibuan, Ahmad, & Harahap, 2023). This problem-solving ability is one of the skills needed to face technological advancements in the era of Society 5.0, helping to enhance students' analytical skills and get them accustomed to solving problems in various situations (Ramadhan et al, 2023). One way to improve problem-solving skills is through mathematical literacy (Purnama et al, 2023).

Mathematical literacy is closely related to the objectives of teaching mathematics as mentioned in the Regulation of the Minister of National Education Number 22 of 2006, which aims to enable students to reason based on models and characteristics of thinking, make generalisations from mathematical operations, construct proofs, or explain mathematical ideas and statements (Juniansyah, Mariyam, & Buyung, 2023). Mathematical literacy is defined as an individual's capacity to formulate, use, and interpret mathematics in various contexts. It involves mathematical reasoning and the use of mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena. This capacity aids in understanding the role of mathematics in daily life and making decisions needed by an active, engaged, and reflective society (OECD, 2013). This literacy helps students understand the functions, principles, and applications of mathematics, enabling them to solve problems accurately in real life (Hayati & Kamid, 2019). An important aspect of this skill is the ability to interact with, apply, and explain mathematics in various situations (Pamungkas & Franita, 2019).

The mathematical literacy skills of students in Indonesia have not been encouraging at the international level, according to the PISA (Program for International Students Assessment) evaluations, which have been conducted since 2000. The results have consistently been below the international average (Yuberta, Nari, & Gustia, 2020). In 2015, Indonesia ranked 63rd out of 69 countries in mathematical literacy with an average score of 386, below the international average score of 500. In 2018, Indonesia ranked 73rd out of 79 countries with an average score of 379, still below the international average of 500 (Hewi & Shaleh, 2020). In 2022, Indonesia scored 366, lower than the 2018 results (OECD, 2023). This indicates that mathematical literacy skills are still relatively low in Indonesia (Hapsari, 2019).

Regarding the low mathematical literacy skills, as evidenced by the pre-research test results at SMP N 5 Magelang, which only obtained an average score of 38,4. Many students still struggle to solve the problems given in the questions. Students are also unable to represent the given problems accurately, and the solutions provided are still incorrect due to inappropriate strategies used. Additionally, students are not yet accurate in concluding the given problems. Observations show that the learning process is still teacher-centred with the direct instruction model, and student involvement is less active. Students also seem less enthusiastic about the learning process, leading to a lack of understanding of the material explained by the teacher.

Given this situation, there is a need for a solution to create learning that fits the students' conditions. One way to achieve this is by selecting an appropriate learning model. One such model is Challenge Based Learning (CBL), which can be used as an effort to improve literacy because it includes a challenge phase that increases students' curiosity about learning (Mardhiyah, 2019). The learning process with this model is intended to be engaging, demanding, and participatory (Susilawati & Suryadi, 2020).

The CBL model is a challenge-based learning model that combines project-based, problem-based, and contextual learning models. It focuses on solving real-life problems in everyday life and has the following steps: big Idea, essential question, the challenge, guiding question, guiding activities, guiding resources, solution-action, assessment, publishing (Johnson et al, 2009). The challenge in this model is also to address students' lack of interest in learning due to the shift from playing with friends to sitting quietly and listening to the teacher's explanation. In this model, students will learn together in groups to solve the given challenge, so the change in the learning environment is not as noticeable to the students (Kurniawati, Mardhiyah, & Miftah, 2019). Applying CBL provides students with the opportunities and challenges to engage directly with the phenomenon in real life, allowing them to build their understanding based on their experiences (Nufus, Duskri, & Bahrun, 2018).

Research supporting this study includes the work by Alfiany, Kurniawati, & Andriatna (2024), which demonstrated that the application of the CBL model yields better results compared to other models in enhancing students' mathematical literacy skills. Therefore, this model has the potential to be implemented in order to improve students' mathematical literacy. The stages of this model are able to help students become more active in learning because they are required to think about how to solve the given problems, which becomes a challenge for the students (Anwar & Ardiansyah, 2024). These challenges arise from real-world problems, which then encourage students to brainstorm solutions to the challenges presented. (Rahmatillah & Ardiansyah, 2023).

Based on the discussion, this research aims to analyse: 1) the completeness of mathematical literacy skills of students who follow the learning process using the CBL model, 2) the completeness of mathematical literacy skills of students who follow the learning process using the direct instruction model, & 3) the effectiveness of the CBL model compared to the direct instruction model on students' mathematical literacy skills.

METHODS

The research method used in this study is quasi-experimental with a pre-test, post-test, and nonequivalent control group design. This study was conducted in experimental and control classes by providing different learning models, with the experimental class using the Challenge Based Learning (CBL) model and the control class using the direct instruction model.

The population of this study is all students of Class IX at SMP N 5 Magelang. The sample was obtained using the cluster random sampling technique, resulting in Class IX D as the experimental class with a total of 30 students and Class IX E as the control class with a total of 29 students. Data collection techniques include observation, interviews, tests, and documentation.

The research instruments used are observation sheets, interview guidelines, validation sheets, and tests. The tests consist of essay questions prepared based on indicators of mathematical literacy skills. These indicators include mathematisation, representation, designing strategies to solve problems, and reasoning and argumentation. Students are considered to have achieved competency if they meet the Learning Objective Achievement Criteria set by the school, which is ≥ 75 .

Data analysis in this study includes initial data analysis in the form of pre-tests and final data analysis in the form of post-tests with prerequisite tests, namely normality tests using the Lilliefors test and homogeneity tests using the F-test. Initial data is then analysed using an independent sample t-test to determine the similarity of the averages in both classes. Final data analysis includes hypothesis testing in the form of a proportion test to determine completeness in both classes and an independent sample t-test to determine which learning model is more effective between the experimental and control classes.

RESULTS & DISCUSSION

Results

The initial data in the form of pre-tests of students' mathematical literacy skills in both classes was conducted before both classes received instruction. The results show that the average mathematical literacy skills in both classes need to be improved because they

have not yet met the Learning Objective Achievement Criteria set by the school, which is ≥ 75 . The pre-test results are shown in Table 1.

Table 1. Pre-test Results of Mathematical Literacy Ability

Class	n	X_{\max}	X_{\min}	Average
Experimental	30	76,67	15,00	50,50
Control	29	73,33	16,,67	49,60

The initial data analysis of the pre-test results on students' mathematical literacy skills was conducted using prerequisite tests, namely normality and homogeneity tests. The normality test results showed that $L_{count} < L_{table}$, with $L_{count} = 0,0987$ and $L_{table} = 0,1614$ in the experimental class, and $L_{count} = 0,1359$ and $L_{table} = 0,1641$ in the control class, indicating that H_0 is accepted, meaning the data is normally distributed. The homogeneity test results showed that $F_{count} < F_{table}$, with $F_{count} = 1,2134$ and $F_{table} = 1,8752$, indicating that H_0 is accepted, meaning the data is homogeneous. After conducting the prerequisite tests, the independent sample t-test was performed, showing that H_0 is accepted because $-t_{table} \leq t_{count} \leq t_{table}$, with $t_{count} = 0,2504$ and $t_{table} = 2,0025$, meaning there is no significant difference in the average mathematical literacy skills of students in both classes. The results of the independent sample t-test calculations are shown in Table 2.

Table 2. Results of Initial Data Mean Equality Test Calculations

	n	Average	t_{count}	t_{table}	Decision
Experimental	30	50,50	0,2504	2,0025	H_0 accepted
Control	29	49,60			

After the pre-tests, both classes were given treatment in the form of learning model implementation. The experimental class used the CBL model, while the control class used the direct instruction model. Post-tests were then conducted to obtain the final data on mathematical literacy skills after the learning process. The post-test results show that the average mathematical literacy skills in both classes meet the Learning Objective Achievement Criteria. The post-test results for both classes are shown in Table 3.

Table 3. Post-test Results of Mathematical Literacy Ability

Class	n	X_{\max}	X_{\min}	Average
Experimental	30	96,67	58,33	82,50
Control	29	93,33	55,00	76,78

The final data analysis of the post-test results used prerequisite tests, namely normality and homogeneity tests. The normality test results showed that $L_{count} < L_{table}$, with $L_{count} = 0,1063$ and $L_{table} = 0,1614$ in the experimental class, and $L_{count} = 0,1290$ and $L_{table} = 0,1641$ in the control class, indicating that H_0 is accepted, meaning the data is normally distributed. The homogeneity test results showed that $F_{count} < F_{table}$, with $F_{count} = 1,1891$ and $F_{table} = 1,8752$, indicating that H_0 is accepted, meaning the data is homogeneous.

After the prerequisite tests were fulfilled, a proportion test was conducted to address Hypothesis 1 and Hypothesis 2. Hypothesis 1 was used to determine the completeness of learning outcomes in the mathematical literacy skills of students in the experimental class using the CBL model. The calculation results showed that $Z_{count} > -Z_{table}$, meaning H_0 is accepted. The hypotheses for Hypothesis 1 are H_0 : the proportion

of students who received learning with the Challenge Based Learning model has reached completeness of 75%, and H_1 : the proportion of students who received learning with the Challenge Based Learning model has not reached completeness of 75%. Thus, it can be concluded that the proportion of students who received learning with the Challenge Based Learning model has reached a completeness of 75%.

As for Hypothesis 2, it was used to determine the completeness in the control class using the direct instruction model. The calculation results showed that $Z_{\text{count}} > -Z_{\text{table}}$, meaning H_0 is accepted. Thus, it can be concluded that the proportion of students who received learning with the direct instruction model has reached a completeness of 75%. The calculation results for completeness in Hypothesis 1 and Hypothesis 2 are shown in Table 4.

Table 4. Calculation Results of Completeness Test

Class	Number of Students Completed	n	Z_{table}	Z_{count}	Decision
Experimental	25	30	1,64	1,05	H_0 accepted
Control	22	29	1,64	0,11	H_0 accepted

Next, Hypothesis 3 was tested to compare the average mathematical literacy skills in both classes after the learning process. The hypothesis test was conducted using the independent sample t-test. The calculation results showed that $t_{\text{count}} > t_{\text{table}}$, meaning H_0 is rejected. Thus, it can be concluded that the average mathematical literacy skills of students who received learning with the Challenge Learning model are better compared to the average mathematical literacy skills of students who received learning with the direct instruction model. The calculation results are shown in Table 5.

Table 5. Results of Average Test Calculations

Class	n	Average	t_{count}	t_{table}	Decision
Experimental	30	2,50	2,0115	2,0025	H_0 Rejected
Control	29	6,78			

Discussion

The implementation of the Challenge Based Learning (CBL) model in the experimental class achieved completeness. This was due to the steps in this model that could help improve students' mathematical literacy skills. This is in line with research by Ayuzalpiah (2022), which showed that the application of the CBL model can improve students' mathematical literacy skills. This learning model has an efficient and effective framework for learning by solving real-world challenges (Nichols, Cator, & Torres, 2016)

The steps in this model include the big idea, essential question, challenge, guiding question, guiding activities and resources, solutions, and assessment. In the big idea phase, the teacher presents the main idea, which becomes the primary focus of learning. The main idea is presented through worksheets with reading materials consisting of real-life problems that need to be solved. The application of the CBL model helps students in solving the given problems (Syaharani, Agoestanto, & Asih, 2024). Meanwhile, problem-solving is one of the main competencies in mathematical literacy (Rizki & Priatna, 2019).

In the second phase, students are given essential questions that arise from the main idea to help complete the next step, which is the challenge. This challenge can help students become active in learning and develop a deeper understanding of the concepts presented (Nawawi, 2016). This conceptual understanding is needed to describe the process of mathematical literacy (Purnama et al., 2023).

Next, students are given guiding questions based on the challenge presented. These questions are designed to help students develop strategies to solve the challenge. Developing these strategies is one of the fundamental mathematical skills in assessing mathematical literacy (OECD, 2013).

In the next stage, the teacher assists students in answering guiding questions and finding solutions by presenting the lesson material and supporting it with reference books, which is the guiding activities and resources phase. These activities can help students find solutions (Haqq, 2017). Then, in the solutions phase, students provide conclusions from the solutions found in the worksheets. In this phase, students present solutions in the form of mathematical resolutions to the given challenges. The learning process ends with students presenting their solution results in front of the class as part of the assessment phase. Presenting in front of the class can help improve students' mathematical communication skills (Ermawati, 2022). Mathematical communication is in line with mathematical literacy (Samawati & Kurniasari, 2021). One of the goals of mathematical literacy is for students to be able to communicate their ideas (Pantaleon, Nendi, & Jehadus, 2019).

The learning process in the control class using the direct instruction model also achieved completeness. This is due to the steps in this model that help students improve their mathematical literacy skills. The steps in this model include preparation, demonstration, practice, checking understanding and providing feedback, and advanced practice. Demonstration in the implementation of this model can enhance students' understanding of mathematical concepts needed to assess students' mathematical literacy skills (Lutfiyana, Dwijayanti, & Pramasdyahsari, 2022). This is in line with the opinion of Genc & Erbas (2019) that understanding mathematical concepts forms the basis of mathematical literacy. The practice provided also consists of application problems in everyday life designed to be solved according to the indicators of these mathematical literacy skills. Through the given practice, mathematical reasoning is required to solve them, while mathematical reasoning is a basic competency in mathematical literacy (Kusumawardani, Wardono, & Kartono, 2018). This aligns with the opinion of Kelana et al, (2020) who state that mathematical reasoning is one of the competencies in mathematical literacy.

However, in practice, there are still some students who do not pay attention to the teacher's explanation and choose to talk with other classmates. Students also quickly feel bored during the learning process because the instruction is teacher-centered. As a result, students' focus on the learning process decreases. During the lessons, students only listen to the teacher's explanations without asking about things they do not understand. Consequently, these students' mastery of the material is still lacking. Meanwhile, mastering the material, especially prerequisite material, will help students answer mathematical literacy questions well (Usman & Kristiawati, 2022).

During the practice phase, through group discussions to complete worksheets, there are still students who do not actively participate in the discussions and only rely on their group members. Meanwhile, students' activeness can affect their mathematical literacy skills (Kusumawati, Purwosetiyono, & Handayani, 2024).

Unlike the experimental class, which showed that students were more actively involved in learning due to the challenges provided, the students who received direct instruction were less engaged. The challenges given also encouraged students to use their critical thinking skills (Ardiansyah, Agung, Cahya, & Dinasari, 2022). Critical thinking skills are related to mathematical literacy skills; if critical thinking skills are high, then mathematical literacy skills will also be high (Sukmawati, 2018).

Based on these differences, the post-test results of students after receiving instruction indicate that the implementation of the Challenge Based Learning (CBL) model is more effective than direct instruction in improving students' mathematical literacy skills.

As noted in the research by Ayuzalpia (2022), the CBL model is more effective than the lecture method in enhancing students' mathematical literacy. This finding is also consistent with the research by Firdaus, Wahyudin, & Herman (2017), which shows that direct instruction is less effective than other models in improving students' mathematical literacy.

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CONCLUSION

Based on the research results and the discussion presented, it can be concluded that 1) the mathematical literacy skills of students who received instruction with the CBL model achieved completeness; 2) the mathematical literacy skills of students who received instruction with the direct instruction model achieved completeness; and 3) the Challenge Based Learning (CBL) model is more effective than the direct instruction model in improving students' mathematical literacy skills. The recommendations from this research are as follows: 1) educators are advised to not only focus on delivering material but also practice application-oriented problems that can help improve students' mathematical literacy skills; 2) educators are also expected to create a more conducive classroom environment and encourage students to be more active in their learning; 3) for other researchers, the findings of this study can be used as a reference for similar research on different subjects; and 4) this research can be expanded by incorporating other variables such as different abilities, learning styles, and more.

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