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Implementation of Problem-Based Learning Based on Culturally Responsive Teaching to Improve Students' Mathematical Literacy

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ABSTRACT

Mathematical literacy is essential for students to face the challenges of the 21st century. This ability encompasses mastery of mathematical concepts and procedures, reasoning skills, and the capacity to solve contextual problems. PBL is a learning model that solves real-world problems. However, its application in a culturally relevant context that aligns with students' experiences and backgrounds remains limited. This study examines the application of CRT-based PBL to improve students' mathematical literacy. The CRT approach emphasizes linking the learning environment with local culture, while PBL is a problem-based learning model. To increase student engagement in the learning process, the problem context used is the students' local culture. The research method used is CAR, with two learning cycles including planning, implementation, observation, and reflection. Data analysis of mathematical literacy test results used quantitative and qualitative descriptive analysis techniques. To measure changes in mathematical literacy, data collection was carried out through mathematical literacy tests and observations. Based on the results of data analysis, there was an increase in the average post-test score of students in each learning cycle. Therefore, it proves that the implementation of the CRT-based PBL model can improve mathematical literacy and student engagement in the learning process. Students could also relate mathematical concepts to cultural contexts familiar to them. Therefore, PBL combined with CRT can be an alternative solution to optimally enhance students' mathematical literacy by providing relevant and meaningful learning experiences.

Keywords: *Problem-based learning, culturally responsive teaching, mathematical literacy*

Implementasi Problem-Based Learning Berbasis Culturally Responsive Teaching untuk Meningkatkan Literasi Matematis Peserta Didik

ABSTRAK

Literasi matematis merupakan kemampuan penting yang harus dimiliki oleh peserta didik dalam menghadapi tantangan abad ke-21. Kemampuan ini tidak hanya mencakup penguasaan konsep dan prosedur matematika, tetapi juga melibatkan kemampuan bernalar, dan memecahkan masalah kontekstual. PBL merupakan model pembelajaran yang berfokus pada pemecahan masalah kontekstual. Akan tetapi, penerapannya dalam konteks budaya yang relevan dan sesuai dengan pengalaman serta latar belakang peserta didik masih terbatas. Penelitian ini mengkaji penerapan PBL berbasis CRT untuk meningkatkan literasi matematiks peserta didik. Hal yang ditekankan pada pendekatan CRT adalah mengaitkan lingkungan belajar dengan budaya setempat, sedangkan PBL merupakan model pembelajaran berbasis masalah. Untuk meningkatkan keterlibatan peserta didik dalam proses pembelajaran, konteks masalah yang digunakan adalah budaya lokal peserta didik. Metode penelitian yang digunakan adalah PTK, dengan dua siklus pembelajaran meliputi perencanaan, pelaksanaan, observasi, dan refleksi. Analisis data hasil tes literasi matematiks menggunakan teknik analisis desktiptif kuantitatif dan kualitatif. Untuk mengukur perubahan literasi matematis, pengumpulan data dilakukan melalui tes literasi matematika dan observasi. Berdasarkan hasil analisis data, terjadi peningkatan skor rata-rata post-tes siswa pada setiap siklus pembelajaran. Siswa juga mampu mengaitkan konsep matematika dengan konteks budaya yang dikenalnya. Oleh karena itu, PBL yang dikombinasikan dengan CRT dapat digunakan sebagai alternatif solusi untuk meningkatkan literasi matematis peserta didik secara optimal dengan memberikan pengalaman belajar yang relevan dan bermakna.

Kata Kunci: *Problem-based learning, culturally responsive teaching, literasi matematis*

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1. Introduction

In the era of globalization and the Fourth Industrial Revolution, mathematical literacy has become one of the essential competencies that students must possess. According to the OECD (2021), mathematical literacy is an individual's ability to formulate problems (formulate), use concepts, facts, and procedures (employ), and reinterpret them in the given problem context (interpret). Mathematical literacy is related to understanding mathematical concepts and applying mathematical knowledge in various real-life situations (OECD, 2019). The OECD defines mathematical literacy in the PISA draft (OECD, 2021) as an individual's capacity to reason mathematically in formulating, applying, and interpreting mathematics to solve problems within real-world contexts. Mathematical literacy is a powerful tool for students to succeed in academic activities and contribute meaningfully to society (Sujatha & Vinayakan, 2022). According to Holenstein et al. (2021), mathematical literacy is crucial to include in the school curriculum because it positively correlates with student academic achievement. When educators and policymakers invest in mathematical literacy, students will benefit in terms of their future academic achievement.

Mathematical literacy in Indonesia faces significant challenges, as evidenced by various studies highlighting students' abilities in complex problem-solving and conceptual understanding. The 2022 PISA results show that less than 1% of Indonesian students achieved a high level of proficiency (Husni & Herman, 2024). The mathematical literacy of students in Indonesia remains below the international average, as reported by various global education surveys, including the Programme for International Student Assessment (PISA)

(Kemendikbud, 2020). Many students struggle to connect mathematical concepts with real-life contexts. Several factors contribute to the low mathematical literacy in Indonesia: (1) Teacher-centred learning approaches (Nurwahid & Ashar, 2022); (2) Lack of connection between learning materials and the cultural context known to students (Setiawan & Ariyanti, 2021); (3) Lack of skills in interpreting contextual problems into mathematical problems (Kholid & Nissa, 2022); (4) Lack of practice with literacy questions, and difficulty in applying mathematics to real-world problems (Nurwahid & Ashar, 2022); (5) Limited student experience in solving situational problems (Tanjung et al., 2023); (6) Teacher misconceptions in developing effective mathematical literacy understanding in the classroom (Ramsay-Jordan, 2020). Lubis et al., (2024) claim, effective learning strategies, including problem-based instruction and problem-based learning, can improve mathematical literacy.

Based on observations and reflections on learning in grades XII-9 of SMAN 6 Malang, many students still struggle to understand mathematical concepts, especially when solving contextual problems that require logical reasoning. This is evident in students' passive responses and lack of confidence during the learning process. Teachers' learning is also still abstract and has not yet been linked to the local cultural context or students' experiences. As a result, the teaching is less meaningful and does not provide students with the opportunity to actively participate in the process of building knowledge. To make learning more relevant and meaningful for students, teachers should be able to utilize local culture as a learning resource effectively. Cultural values have been proven to be effective in improving students' mathematical literacy (Fernanda, et al., 2024). The integration of cultural values, combined with pedagogical actions, successfully engaged students in algebraic reasoning. The use of cultural artifacts related to students' lives is important because it can serve as a platform that allows students to make progress in thinking about mathematics (Hunter & Miller, 2022). According to Hajeniati & Kaharuddin (2022), innovative learning models, such as problem-based learning combined with contextual learning, can increase student engagement. Furthermore, they can train students' literacy skills in practical, real-world tasks that encourage critical thinking and collaboration (Simanjuntak et al., 2021). Therefore, a solution that combines the PBL model with CRT has emerged to address these issues.

PBL is a learning model that involves students in problem-solving activities, improving critical thinking skills through real-life contexts, and collaborative tasks (Redrobán & Durán, 2024; Sari & Arifin, 2020). Meanwhile, CRT emphasizes the importance of adapting learning to the cultural background of students to create a learning environment that accommodates cultural diversity and student engagement (Gay, 2018). In mathematics education, this approach enables teachers to integrate local cultural elements into math lessons, making mathematical concepts more relevant and easier for students to understand (Hickman & Koss, 2020). CRT seeks to bridge the gap between local culture and the culture of students by adapting learning materials to be more relevant to students (Ladson-Billings, 2020). Studies show that student achievement improves when cultural elements are integrated into the curriculum, as demonstrated by the application of culture in math learning (Sulaiman et al., 2024). Implementing CRT in math classrooms has increased student engagement and learning outcomes, with completion rates rising from 43.75% to 81.25% over two cycles of classroom action research (Rahmah et al., 2023). As evidenced by the increase in completion rates and average scores in various studies, it shows that PBL associated with CRT can significantly improve student performance (Molita et al., 2024; Andelia et al., 2024).

Previous studies conducted by Salma et al., (2023) and Safirah et al., (2024) have demonstrated that the PBL model effectively enhances students' critical thinking skills, problem-solving abilities, and conceptual understanding of mathematics. Additionally, Asmaliyah et al., (2025) indicated that implementing the PBL model integrated with a CRT approach can improve students' motivation and academic achievement. Previous studies have focused only on cognitive aspects and have not yet deeply considered cultural factors, social background, and student identity in the learning process. Socio-cultural context plays a significant role in shaping how students understand, respond to, and engage in the learning process, including mathematics education. Another limitation is the lack of research explicitly connecting CRT with the improvement of mathematical literacy, even though mathematical literacy greatly benefits from the context that is relevant and meaningful to students' lives. Existing studies address mathematical literacy in general terms without considering how students' cultural experiences can be leveraged as a strength in understanding and solving mathematical problems. Therefore, this study seeks to address this gap by integrating a CRT-based PBL model to enhance students' mathematical literacy through a reflective, contextual, and student-centred action research approach. By implementing CRT-based PBL, it is expected that students will be able to learn mathematics more meaningfully, which is connected to their everyday lives, while also developing problem-solving skills and fostering active participation. This, in turn, can cultivate mathematical literacy through a comprehensive understanding of mathematical concepts and methods. The results of this study are expected to contribute to the development of culturally relevant mathematics teaching strategies that can be adapted by educators across various contexts.

2. Research Method

This study employs a Classroom Action Research (CAR) method, consisting of two cycles, each allocated 3 × 45 minutes. The research was conducted during the independent teaching practicum of the Pre-service Teacher Professional Education (PPG Prajabatan) program at SMAN 6 Malang, Class XII-9, for the 2024/2025 academic year, involving 33 students. This class was selected based on pre-cycle data from the school's general proficiency test on intelligence aspects. Additionally, classroom observations in Class XII-9 revealed that students frequently struggled with translating information from word problems into mathematical symbols. Based on this data, the mathematical literacy level of students in Class XII-9 at SMAN 6 Malang was classified as low. The instruments used in this study include (1) Student Worksheets on Vector Material Using PBL-Based CRT: Used as instructional materials to help students understand problems related to vectors; (2) Mathematical Literacy Test on Vector Material with a CRT Approach: A test designed to measure students' mathematical literacy improvement before and after implementing the PBL-based CRT model. This test is developed based on mathematical literacy indicators, as outlined in Table 1. Before the mathematical literacy test was administered to the students, a validation process was first conducted by a mathematics education lecturer and a teacher from SMAN 6 Malang. The test items were developed based on the mathematical literacy framework, which encompasses formulating, applying, and interpreting mathematical problems within real-life contexts; (3) Observation Sheets: Used to record student activities and responses during the learning process. The success of this research is determined by the increase in the average percentage of mathematical literacy test scores in Class XII-9 at SMAN 6 Malang. The results are obtained through post-tests conducted at the end of each cycle. Data from the mathematical literacy tests are analysed by comparing pre-test and post-test results to assess improvement.

Each cycle in this study follows the four-stage process outlined by Kemmis & McTaggart (1988): planning, implementation, observation, and reflection. The cycle in CAR is repeated until students' achievement shows improvement, as shown in Figure 1.

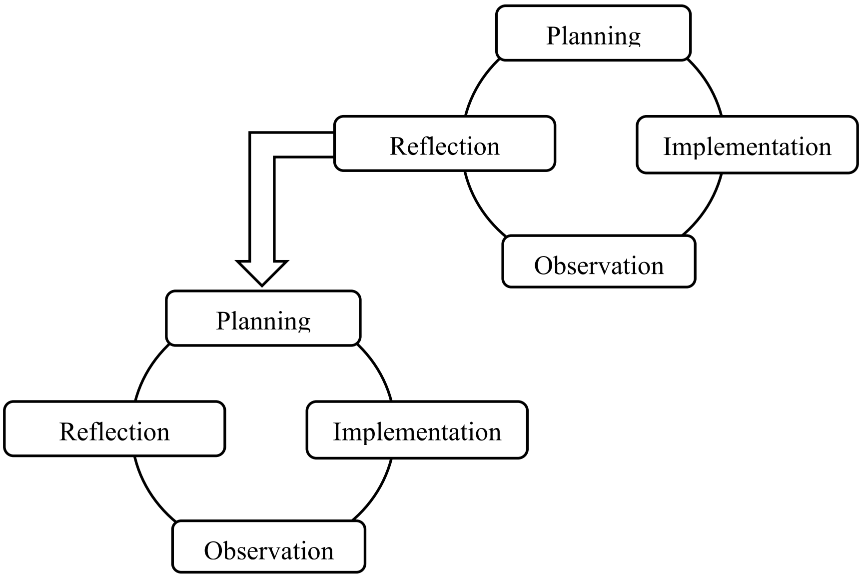

Figure 1. The Cycle of Classroom Action Research

Researchers use this method to identify problems in the learning process, make improvements, and then directly observe the changes that occur. Several stages were carried out by the researchers: (1) Planning: Researchers develop a lesson plan by integrating the PBL-based CRT model into the vector material; (2) Implementation: The designed lesson plan is carried out by implementing problem-based learning (PBL) and culturally responsive teaching (CRT) in class XII-9 at SMAN 6 Malang; (3) Observation: Researchers monitor student engagement and the effectiveness of the learning process; (4) Reflection: At the end of each cycle, an evaluation is conducted to analyze the results and determine improvement plans for the next cycle.

The mathematical literacy indicators in this study are adapted from the PISA 2021 framework (OECD, 2021), which consists of three key components: formulating problems (formulate), applying concepts (employ), and interpreting results (*interpret*). These indicators are presented in Table 1 as a reference for assessing students' mathematical literacy.

Table 1. Mathematical Literacy Indicators

Process	Mathematical Literacy Indicators
a. Formulating problems (Formulate)	1. Identifying mathematical aspects within the given problem context. 2. Converting identified mathematical aspects into symbols or mathematical models.
b. Applying concepts (Employ)	1. Designing and applying mathematical concepts to solve the given problem context. 2. Using mathematical procedures or algorithms in the process of finding solutions.
c. Interpreting results (Interpret)	1. Interpreting the solution results within the given problem context. 2. Evaluating the appropriateness of the solution results in the given problem context.

In its implementation, the researcher requires a supporting instrument: a mathematical literacy test sheet containing one problem related to vector material. The mathematical literacy post-test used in this study is shown in Figure 2 and 3.

A tourist visiting the city of Malang wishes to explore two well-known historical landmarks: the Singosari Temple and the Malang Monument. The starting point of the tourist's journey is the Singosari Temple, located at coordinate R (3,2), and the endpoint is the Malang Monument, located at coordinate S (11,17).

a. Calculate the displacement distance traveled by the tourist.
b. Suppose the tourist continues their journey to the Malang City Square, which lies in a straight line from the Malang Monument and is twice the distance between the Singosari Temple and the Malang Monument. What is the new distance of the tourist's journey?
c. Determine the coordinates of the new endpoint T (Malang City Square)!

Figure 2. First Cycle Mathematical Literacy Post-Test

There are several well-known tourist attractions in Malang, namely Coban Rondo Waterfall (point A), Kampung Biru Arema (point B), and Taman Krida Budaya (point C). A traveler begins their journey from Coban Rondo Waterfall and proceeds to Kampung Biru Arema by walking 4 km eastward and 3 km northward. After visiting Kampung Biru Arema, the traveler continues their journey to Taman Krida Budaya by walking 5 km westward and then 2 km southward.

a. Draw the position and displacement vectors of the traveler from Coban Rondo Waterfall to Kampung Biru Arema and from Kampung Biru Arema to Taman Krida Budaya!
b. Calculate the vector components from Coban Rondo Waterfall to Kampung Biru Arema and from Kampung Biru Arema to Taman Krida Budaya!
c. Calculate the total displacement from Coban Rondo Waterfall to Taman Krida Budaya!

Figure 3. Second Cycle Mathematical Literacy Post-Test

Quantitative and qualitative descriptive analysis techniques analyze the mathematical literacy test data. Quantitative Analysis data from the mathematical literacy tests is analysed using descriptive statistics to observe the increase in average scores from the first to the second cycle. Qualitative Analysis data from the observation sheets is analysed to understand students' responses and engagement during the learning process. The analysis results are used to evaluate the effectiveness of the implemented actions and serve as a reference for improvements in the next cycle.

3 Results and Discussion

Before implementing the intervention (pre-cycle), the learning environment showed low student engagement. Many students were passive during lessons, with only a few responding to teachers' questions. Additionally, pre-cycle data from the school's general proficiency test on intelligence aspects indicated that the mathematical literacy of Class XII-9 at SMAN 6 Malang was relatively low. The primary goal of this study is to enhance students' academic competencies in Class XII-9 at SMAN 6 Malang. This is achieved through the PBL model integrated with CRT, which involves students in digging up information to solve problems independently in groups. In line with Susanty et al., (2024), PBL promotes active learning, as students engage in problem-solving and critical analysis rather than passively receiving information. Balarajasekhar & Suma (2024) also said that CRT acknowledges and incorporates students' cultural backgrounds, enhancing their engagement in the learning process. In this research, the PBL model-based CRT model was implemented using local contexts, such as tourist attractions, cultural traditions, and Malang's signature foods, to make the learning process more relevant to students. According to Procel et al., (2023), teaching practices make students feel valued and acknowledged by integrating relevant cultural contexts into lessons. Arista (2020) also said combining local culture and environmental potential in learning fosters meaningful connections, positively impacting learning processes and outcomes. The findings from each cycle are described in the following explanation:

3.1 First Cycle

The planning stage involved developing several instructional materials, including a Teaching Module on Vector Material, Student Worksheets, Observation Sheets, and Pre-test and Post-test Questions for the first cycle. The student worksheet was explicitly designed to integrate local cultural elements familiar to students. In this case, the learning materials incorporated Malang's cultural heritage, particularly popular tourist attractions, such as Florawisata Santerra De Laponte, Museum Mpu Purwa, and Museum Singhasari. By integrating local culture into math problems, students are encouraged to connect math concepts to real-world applications, making learning more engaging and relevant.

During the implementation stage, several key activities were conducted. A pre-test was administered to assess students' initial mathematical literacy, the designed teaching module was implemented, and students were divided into heterogeneous groups of four to five members to solve problems in the Student Worksheets collaboratively. Heterogeneous grouping allowed students to collaborate, enabling more proficient students to assist their peers who needed support. Students worked together to discover the concept of vector length based on initial and final coordinates, integrating local cultural elements into their learning process. They documented their findings in the Student Worksheets and then presented their results. The teacher provided reinforcement and clarification on the learned concepts. At the end of the learning session, a post-test was administered to evaluate students' mathematical literacy in solving problems related to the material covered. This assessment aimed to measure the achievement of learning objectives in the first cycle and determine the extent of students' improvement.

During the observation stage, student activities and responses were monitored throughout the implementation of the learning approach. Significant events during the learning process were recorded and documented for further analysis. During this stage, the learning process was evaluated based on observational data. Several challenges were identified. Some students were less engaged and did not actively contribute to group discussions. Students with weaker understanding tended to rely on their more proficient peers, resulting in only the high-achieving students actively participating in discussions and presentations. The post-test analysis revealed that students had not yet met the mathematical literacy indicators, specifically in formulating mathematical models, applying mathematical concepts, and interpreting final solutions. As presented in Table 2, these findings highlight the need for further improvements in the next cycle to enhance student engagement and mathematical literacy.

Table 2. Results of the First Cycle Mathematical Literacy Post-Test

Question	Indicator	First Cycle		
		Maximum Score	Average Score	% Achievement
a.	Formulating problems (Formulate)	25	13	52
b.	Applying concepts (Employ)	35	18	51
c.	Interpreting results (Interpret)	40	16	40
	Average			47,67%

Based on the analysis of Table 2, the average percentage of mathematical literacy achievement across all indicators is 47.67%. The achievement rate for the problem formulation stage is 52%, indicating that many students still struggle to identify mathematical aspects within the given problem context and transform known mathematical aspects into mathematical models. When solving problems, most students remain confused about the problem-solving process even after identifying the provided information and the question being asked. This confusion hinders their ability to proceed to the concept application stage, where the achievement rate is 51%. This suggests that many students can still not effectively design and apply mathematical concepts to obtain solutions in the given problem context. Additionally, they have yet to systematically utilize mathematical procedures or algorithms during the derivation of solutions, which ultimately affects the accuracy of the final results. Furthermore, the achievement rate for the result interpretation stage is 40%, demonstrating that students still struggle with evaluating and interpreting the solutions obtained in the context of the given problems.

Based on the analysis of students' achievement in mathematical literacy indicators, it is evident that their mathematical literacy remains suboptimal, particularly in the concept application indicator, which involves designing and utilizing mathematical concepts to derive solutions within a given problem context. Several factors contribute to this issue, including some students' lack of active participation during group discussions in the first cycle. A Song et al., (2023) study highlights that students' engagement in mathematical discussions is closely related to their mathematical literacy. This finding aligns with research by Lyu et al., (2024), student participation, such as technical and social interactions related to learning content, can improve their mathematical literacy. Indirectly, they learn how to communicate effectively and then demonstrate their knowledge. Based on these observations, the researcher will implement improvements in the second cycle to enhance student engagement in the learning process and improve their mathematical literacy.

3.2 Second Cycle

The second cycle was conducted based on the reflection results from the first cycle. The procedures in the second cycle were the same as those in the first, but with several improvements. In the second cycle, the researchers added a digital platform in the form of a Wordwall to increase student interest and identify initial abilities in learning mathematics. Students were enthusiastic and motivated during the pre-test as they completed the questions through the Wordwall application, which used a fun and interactive quiz-game format. In addition, the researcher reorganised the group distribution for working on the Student Worksheets by grouping students with similar ability levels. These modifications were implemented based on the evaluation of the first cycle, aiming to prevent less proficient students from relying too heavily on their more skilled peers. The objective of this strategy was to increase the engagement of all students, ensuring that each student assumes responsibility and plays an active role in the learning process of mathematics.

During the implementation stage, a pre-test was conducted to assess students' initial abilities. The designed instructional module was then implemented, and students were grouped into teams of four to five members with homogeneous skills based on the results of the second cycle pre-test. These groups worked together to solve the problems presented in the Student Worksheets. Following this, students individually took the second cycle post-test. Through group discussions, students were encouraged to collaborate in discovering the concepts of vector addition and subtraction related to local culture. They documented their findings in the Student Worksheets and presented their results. Subsequently, the teacher reinforced the material covered. At the end of the lesson, a post-test was administered to evaluate the extent of students' mathematical literacy in solving problems related to the learned material and to measure the achievement of learning objectives in the second cycle.

During the observation stage, the researcher examined the implementation of the learning process, students' activities and responses during the lesson, and the results of the first and second cycle post-tests. In the reflection stage, the findings indicated that the learning process conducted in the second cycle had met the success indicators. The results from the second cycle demonstrated a significant improvement compared to the first. The average score of students' mathematical literacy using the CRT approach increased. Students' mathematical literacy was measured based on the results of the first and second-cycle post-tests presented in Table 3.

Table 3. Results of the Second Cycle Mathematical Literacy Post-Test

Question	Indicator	First Cycle		
		Maximum Score	Average Score	% Achievement
a.	Formulating problems (Formulate)	25	22	88
b.	Applying concepts (Employ)	35	30	86
c.	Interpreting results (Interpret)	40	30	83
	Average			85,67%

Based on Table 3, the results of students' mathematical literacy tests in the second cycle reached an achievement rate of 85.67%, which indicates a significant improvement from the first cycle. The achievement in the problem-forming stage is 88%, which shows that most students can identify mathematical aspects from the given problem context and transform the known mathematical aspects into a mathematical model. When solving problems, students already understand the solution process after identifying the provided and required information, which does not hinder them in the concept application stage. The achievement in the concept application stage is 86%. Demonstrates that most students can design and apply mathematical concepts to find solutions in the given problem context. However, they have not yet used mathematical procedures or algorithms during the solution-finding process. Which in turn affects the final results obtained. The achievement in the result interpretation stage is 83%. At this stage, some students follow the correct steps in solving problems; however, their final results are incorrect due to a lack of calculation accuracy.

Based on the analysis of the first and second cycles, it is evident that implementing the PBL syntax combined with the CRT approach has a significant positive impact on enhancing the mathematical literacy of class XII-9 at SMAN 6 Malang. The PBL model syntax includes (1) orienting students to a problem; (2) organizing students for learning; (3) guiding individual and group investigations; (4) developing and presenting the final product; and (5) analyzing and evaluating the problem-solving process. Meanwhile, mathematical literacy comprises formulating, employing, and interpreting, as illustrated in Table 1.

The PBL syntax plays a crucial role in improving mathematical literacy skills. In the initial phase, students must observe, identify, and understand the problems provided by the teacher. This phase supports enhancing mathematical literacy, particularly in the formulation process. Various tourist attractions in Malang are the subject of discussion regarding the distance tourist's travel. These problems are undoubtedly relevant to students' daily lives and cultural backgrounds as they live in Malang. This was achieved by encouraging students to actively participate in solving issues related to real-life contexts or cultures relevant to their environment. In line with Song et al., (2024), active participation and effective communication can enhance students' mathematical literacy. This helps foster a sense of being valued and acknowledged in learning.

In the second phase of PBL, students are encouraged to enhance their mathematical literacy through the formulation process, particularly by translating real-world problems into mathematical forms. During this phase, the teacher organises students into several groups. The next step involves collaboration among group members to explore and examine the information provided and determine what needs to be solved in the Student Worksheets. Subsequently, they formulate the problem into a mathematical model. Maralova (2024) state that students' discussion engagement significantly improves mathematical literacy by developing critical thinking and problem-solving skills. Interactive teaching methods, including discussions, allow students to apply mathematical knowledge in real-life contexts, leading to a deeper understanding.

In the third phase of PBL, students are trained to develop mathematical literacy skills through the employing process. They search for information related to mathematical concepts, formulas, and procedures relevant to solving the problems presented in the Student Worksheets. Next, they design a problem-solving strategy and apply it during the problem-solving process.

The fourth phase of PBL supports enhancing students' mathematical literacy through the interpreting process, particularly in interpreting mathematical results. In this phase, students construct solutions to the problems they solved in the previous phase. They then present these solutions to the teacher and classmates, interpreting the mathematical results they have formulated. They also explain their solutions to the original context of the problems. Other students then provide feedback on the presentation.

The fifth phase of PBL plays a role in developing mathematical literacy through the interpreting process, specifically in evaluating the relevance of the obtained results to real-world contexts. In this phase, the teacher and students jointly assess and revise the presented solutions, identifying any errors in the application of problem-solving procedures or in concluding when addressing contextual problems. If errors are found, corrections are made. Subsequently, students are asked to assess whether the solutions they have obtained are relevant to real-life contexts.

After completing the five phases of PBL, students take a post-test individually to determine the effectiveness of the implemented model and approach. The post-test results for the first and second cycles are presented in Tables 2 and 3. The second cycle showed a significant improvement compared to the first cycle. This indicates that most students could identify the mathematical aspects of the given problem context and transform the known mathematical elements into a mathematical model. Therefore, this study was not continued to a third cycle because the students' achievement in each indicator of mathematical literacy improved from the first cycle. Therefore, this study was not continued to a third cycle, as students' achievement in each mathematical literacy indicator showed improvement from the first cycle.

4 Conclusion

The CRT-based PBL learning model has improved the mathematical literacy of grade XII-9 students at SMAN 6 Malang. Based on the research results, mathematical concepts become more relevant to real life, making them easier for students to understand. This is evidenced by a significant increase in students' understanding and application of mathematical concepts. Therefore, the implementation of the CRT-based PBL model can be an effective alternative in mathematics learning, especially in Indonesia, a country with its cultural diversity. To integrate local culture into the learning process, support from various parties is needed, namely, schools and teacher training.

This study has several limitations that necessitate further development. This study employed the CAR method, which is limited to one specific class. The findings are dependent on the characteristics, environment, and local culture of the students at the research site. Consequently, the generalizability of the research findings is limited. Furthermore, further research is needed on the development of local culture-based learning media to improve students' mathematical literacy and overall academic competence.

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6 References

Andelia, I. S. K., Setianingsih, R., & Jannah, F. (2024). Penerapan Problem-Based Learning dan Pendekatan Culturally Responsive Teaching pada Materi Segi Empat untuk Meningkatkan Hasil Belajar Peserta Didik Kelas VII. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *8*(2), 1552–1531. https://doi.org/10.31004/cendekia.v8i2.3242

Arista, H. D. (2020). Utilization of Local Cultural and Environmental Potential as a Source of Learning Indonesian in a Global Context. *ISCE: Journal of Innovative Studies on Character and Education*, *4*(1), 56–69. https://www.iscjournal.com/index.php/isce/article/view/77/70

Asmaliyah, F., Made, N., Keriyani, I., & Nugroho, S. (2025). Meningkatkan Motivasi dan Hasil Belajar Peserta Didik Melalui Penerapan Model Problem Based Learning dengan Pendekatan Culturally Responsive Teaching dalam Pembelajaran Matematika. *Jurnal Ilmiah Profesi Pendidikan*, *10*(1), xx–xx. https://doi.org/10.29303/jipp.v10i1.2172

Balarajasekhar, J., & Suma, V. J. S. (2024). A Study on Enhancing Student Engagement and Achievement through Culturally Responsive Teaching. *International Journal of Scientific Research in Engineering and Management*, *08*(02), 1–13. https://doi.org/10.55041/IJSREM28741

Fernanda, B., Shodikin, A., & Susanah, S. (2024). Mathematics Literacy of Middle School Students with Socio-Cultural Context Viewed from Learning Style. *Jurnal Eksakta Pendidikan (JEP)*, *8*(1), 13-27. https://doi.org/10.24036/jep/vol8-iss1/847

Gay, G. (2018). *Culturally Responsive Teaching: Theory, Research, and Practice (3rd ed.)*. Teachers College Press.

Hajeniati, N., & Kaharuddin, A. (2022). Innovation of the problem based learning model with contextual teaching learning in mathematics learning in the Industrial Revolution 4.0 era: A comparative case studies. *International Journal of Trends in Mathematics Education Research*, *5*(2), 222–227. https://doi.org/10.33122/ijtmer.v5i2.154

Hickman, J. A., & Koss, M. D. (2020). Using Culturally Relevant Pedagogy in Mathematics Classrooms. *Mathematics Education Research Journal*, *32*(4), 659–675.

Holenstein, M., Bruckmaier, G., & Grob, A. (2021). Transfer Effects of Mathematical Literacy: an Integrative Longitudinal Study. *European Journal of Psychology of Education*, *36*(3), 799–825. https://doi.org/10.1007/s10212-020-00491-4

Hunter, J., & Miller, J. (2022). Using a Culturally Responsive Approach to Develop Early Algebraic Reasoning with Young Diverse Learners. *International Journal of Science and Mathematics Education*, *20*(1), 111–131. https://doi.org/10.1007/s10763-020-10135-0

Husni, N., & Herman, T. (2024). Analysis of Students' Mathematical Literacy Ability on High-Level Problems of PISA viewed from Gender. *Jurnal Didaktik Matematika*, *11*(2), 219–234. http://doi.org/10.24815/jdm.v11i2.39445

Kemendikbud. (2020). Hasil PISA 2018: Performa Siswa Indonesia dalam Literasi, Matematika, dan Sains. *Pusat Penilaian Pendidikan*.

Kemmis, S., & McTaggart, R. (1988). *The Action Research Planner*. Deakin University Press.

Kholid, M. N., & Nissa, M. (2022). Students' Math Literacy in Solving PISA-Like Problems in Papuan Local Context. *Al-Ishlah: Jurnal Pendidikan*, *14*(4), 5645–5656. https://doi.org/10.35445/alishlah.v14i4.2258

Ladson-Billings, G. (2020). *The Dreamkeepers: Successful Teachers of African American Children*. John Wiley & Sons.

Lubis, A., Simamora, M. I., Yusnika, Y., & Yani, E. P. (2024). Studi Literatur Strategi Pembelajaran Berdasarkan Literasi Matematika. *Pedagogi: Jurnal Ilmiah Pendidikan*, *10*(2), 170–177. https://doi.org/10.47662/pedagogi.v10i2.746

Lyu, B., Li, C., Li, H., & Xing, W. (2024). Interplay Among Students' Technical, Social, and Content-Related Participation Patterns in an Online Mathematical Discussion Board. *Proceedings of the Eleventh ACM Conference on Learning Scale*, 466–470. https://doi.org/10.1145/3657604.3664696

Maralova, B. (2024). Development and cultivation of mathematical literacy: A pedagogical perspective. *Eurasian Science Review an International Peer-Reviewed Multidisciplinary Journal*, *2*(2), 94–99. https://doi.org/10.63034/esr-55

Molita, A., Widiyanto, R., Ariyanti, G., & Dian, M. (2024). Penerapan Strategi Pendekatan Culturally Responsive Teaching (CRT) dalam Pembelajaran Berdiferensiasi untuk Meningkatkan Hasil Belajar Matematika Peserta Didik Kelas XII-5 SMAN 6 Surabaya. *Journal of Comprehensive Science (JCS)*, *3*(10), 4513–4522. https://doi.org/10.59188/jcs.v3i10.2086

Nurwahid, M., & Ashar, S. (2022). A Literature Review: Efforts to Overcome Student's Mathematical Literacy. *Jurnal Eksakta Pendidikan (JEP)*, *6*(2), 214–221. https://doi.org/10.24036/jep/vol6-iss2/666

OECD. (2019). *PISA 2018 Results: What Students Know and Can Do*. OECD.

OECD. (2021). *Assessment and Analytical Framework*. OECD.

Procel, G. J. O., Tacuri, M. A. P., López, K. A. L., & Criollo, P. I. C. (2023). The Influence of Cultural Context on English Teaching. *Ciencia Latina Revista Científica Multidisciplinar*, *7*(4), 784-800. https://doi.org/10.37811/cl_rcm.v7i4.6920

Rahmah, S. E., Huda, S., & Firmanshah, B. (2023). Improving Mathematics Learning Activity and Outcomes through the Culturally Responsive Teaching (CRT) Learning Approach for Class VII Middle School Students. *Proceeding International Conference on Lesson Study*, *1*(1), 292. https://doi.org/10.30587/icls.v1i1.6971

Ramsay-Jordan, N. (2020). Preparation and The Real World of Education: How Prospective Teachers Grapple with Using Culturally Responsive Teaching Practices in the Age of Standardized Testing. *International Journal of Educational Reform*, *29*(1), 3–24. https://doi.org/10.1177/1056787919877142

Redrobán, J. S., & Durán, V. R. (2024). Problem-Based Learning: A Fundamental Pillar for the Training of Competent Physicians. https://doi.org/10.20944/preprints202410.0955.v1

Safirah, A. D., Ningsih, Y. F., Suhartiningsih, S., Masyhud, M. S., & Hutama, F. S. (2024). Model problem based learning dengan pendekatan culturally responsive teaching terhadap keterampilan berpikir kritis siswa SD. *Jurnal Review Pendidikan Dasar: Jurnal Kajian Pendidikan dan Hasil Penelitian*, *10*(2), 87-96. https://doi.org/10.26740/jrpd.v10n2.p87-96

Salma, I. M., Eurika, N., & Wulandari, F. (2023). Upaya Peningkatan Literasi Sains Siswa Kelas XI MIPA 6 dengan PBL Berbasis Culturally Responsive Teaching Di SMAN Balung. *Education Journal: Journal Educational Research and Development*, *7*(2), 220–230. https://doi.org/10.31537/ej.v7i2.1267

Sari, D. R., & Arifin, S. (2020). Problem Based Learning: New Strategy to Teach Desciptive Text in Speaking. *Lingual: Journal of Language and Culture*, *9*(1), 39–43.

Setiawan, A., & Ariyanti, R. (2021). Integrasi budaya dalam pembelajaran matematika: Sebuah pendekatan berbasis budaya. *Jurnal Inovasi Pendidikan*, *8*(3), 200–215.

Simanjuntak, M. P., Hutahaean, J., Marpaung, N., & Ramadhani, D. (2021). Effectiveness of Problem-Based Learning Combined with Computer Simulation on Students' Problem-Solving and Creative Thinking Skills. *International Journal of Instruction*, *14*(3), 519–534. https://doi.org/10.29333/iji.2021.14330a

Song, Y., Xing, W., Li, C., Tian, X., & Ma, Y. (2024). Investigating the relationship between math literacy and linguistic synchrony in online mathematical discussions through large-scale data analytics. *British Journal of Educational Technology*, *55*(5), 2226-2256. https://doi.org/10.1111/bjet.13444

Song, Y., Xing, W., Tian, X., & Li, C. (2023). Are We on the Same Page? Modeling Linguistic Synchrony and Math Literacy in Mathematical Discussions. *In LAK23: 13th International Learning Analytics and Knowledge Conference*, 599–605. https://doi.org/10.1145/3576050.3576082

Sujatha, S., & Vinayakan, K. (2022). Mathematical literacy for the future: a review of emerging curriculum and instructional trends. *International Journal of Applied and Advanced Scientific Research*, *7*(2), 65-71. https://ijaasr.dvpublication.com/uploads/676bc88b7e4a6_422.pdf

Sulaiman, S., Yendri, O., Suhirman, L., Rachmandhani, S., Baka, C., Djayadin, C., & Napitupulu, B. (2024). *Metode & Model Pembelajaran Abad 21: Teori, Implementasi dan Perkembangannya*. PT. Green Pustaka Indonesia.

Susanty, A. I., Artadita, S., Neo, T. K., Neo, M., Pradana, M., & Amphawan, A. (2024). The Nexus of Cooperative Learning and Problem-Based Learning: A Meta-Analysis. *International Conference on Electrical, Computer and Energy Technologies*, *1*(5). 10.1109/ICECET61485.2024.10698055

Tanjung, A. L., Zulkardi, Z., & Putri, R. I. I. (2023). The development of PISA-like problems using immunity context during pandemic. *Jurnal Elemen*, *9*(1), 31–48. https://doi.org/10.29408/jel.v9i1.6152