



## **Integrated Problem Based Learning Differentiated Instruction: An Effort to Improve Students' Literacy Numeracy Skills**

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### **ABSTRACT**

The critical problem in this research is the lack of instructional strategies that simultaneously enhance literacy and numeracy skills while addressing students' diverse learning needs. While the Problem Based Learning model fosters problem-solving, its implementation often overlooks individual differences, making its integration with differentiated instruction crucial and challenging. One of the mathematical skills that students must have is literacy numeracy skills. However, based on initial observations at one of the public senior high schools in Kuningan, students' literacy and numeracy abilities are still low. This study aims to examine the effectiveness of the Integrated Problem Based Learning Differentiated Instruction model in improving high school students' literacy and numeracy skills. The research employed an experimental method with a one-group pre-test and post-test design involving 36 class XI students. Data were collected through literacy numeracy tests administered before and after the intervention. Data analysis was conducted using N-gain to measure the improvement in students' literacy numeracy ability. The research results were obtained from test results N-Gain, with scores of 0.56 (medium category) and an increase percentage of 56.05%. Students show better abilities in understanding, interpreting, and analyzing problem-based questions related to mathematical concepts

Keywords: Differentiated approach, literacy numeracy, Problem Based Learning

### **ABSTRAK**

*Masalah kritis dalam penelitian ini adalah kurangnya strategi pembelajaran yang secara bersamaan dapat meningkatkan keterampilan literasi dan numerasi sekaligus mengakomodasi kebutuhan belajar siswa yang beragam. Meskipun model Problem-Based Learning mendorong pemecahan masalah, penerapannya sering kali mengabaikan perbedaan individu, sehingga integrasinya dengan Pembelajaran Berdiferensiasi menjadi penting dan menantang. Salah satu keterampilan matematika yang harus dimiliki siswa adalah keterampilan literasi numerasi. Namun, berdasarkan hasil observasi awal di salah satu SMA negeri di Kuningan, kemampuan literasi numerasi siswa masih rendah. Penelitian ini bertujuan untuk menguji efektivitas model Problem Based Learning yang terintegrasi pendekatan berdiferensiasi dalam meningkatkan literasi numerasi siswa SMA. Penelitian ini menggunakan metode eksperimen dengan desain one-group pre-test post-test, melibatkan*



seluruh populasi sebanyak 36 siswa kelas XI. Data dikumpulkan melalui tes literasi numerasi yang diberikan sebelum dan sesudah intervensi. Analisis data dilakukan menggunakan *N-gain* untuk mengukur tingkat peningkatan kemampuan literasi numerasi siswa. Hasil penelitian diperoleh dari uji *N-gain*, dengan skor 0,56 (kategori sedang) dan persentase peningkatan sebesar 56,05%. Siswa menunjukkan peningkatan dalam memahami, menafsirkan, dan menganalisis soal berbasis masalah yang berkaitan dengan konsep matematika.

*Keyword: Pendekatan Berdiferensiasi, Literasi Numerasi, Problem Based Learning*

## INTRODUCTION

Mastery of mathematics is essential for everyone. Mathematics is taught at all levels of education, from elementary to high school, to support national education goals. In this era of globalization, mathematics plays a crucial role in preparing the younger generation to face modern challenges (Pangaribuan & Ginting, 2022). Furthermore, mathematics is a compulsory subject in the curriculum at all levels of formal education (Pusporini et al., 2023). The mastery of mathematics taught at all levels of schooling emphasises computational skills and must be supported by strong literacy.

Literacy is the ability to process information through various stages of thinking (Yulia et al, 2023). In line with this, the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2013) explains that literacy includes the ability to identify, understand, interpret, create, communicate, and write in various contexts. Additionally, literacy serves as a means for individuals to develop their potential and actively participate in social environments (Ferrari, 2012; Rosenberg, 2012). Therefore, literacy plays a fundamental role in the learning process.

One essential aspect of literacy that needs to be developed is numeracy literacy (Yulia et al., 2023). Numeracy literacy is a subset of mathematical literacy that enables individuals to recognize the role of mathematics in daily life and make informed decisions (Meeks et al., 2014). In line with this perspective, PISA (2012) defines mathematical literacy as an individual's capacity to formulate, use, and interpret mathematics in various contexts. Numeracy literacy is closely related to mathematics, and literacy skills in mathematics are key to academic success (Fajri et al., 2022). Indonesia's numeracy literacy score declined by 13 points in the 2023 PISA results even though the country rose five places. With a score of 366, Indonesia is 106 points behind the world average, and 82 percent of students are still below level two (OECD, 2023). Indonesian students' numeracy literacy skills are low because students are not yet optimal in developing mathematical thinking, mathematics learning has not yet accustomed to reflection and application of critical thinking, students' answers tend to be mechanistic without strong reasoning, and mathematics has not been practical in training critical thinking, so students receive more information without deep understanding (Mastuti et al., 2023).

If students lack literacy and numeracy, it is necessary to conduct needs assessments, implement specialized learning, provide teacher training, use interactive media, involve parents, and carry out regular evaluations to monitor and adjust learning strategies/methods (Alfiah & Zulfitria, 2024). This highlights the importance of a more dynamic and responsive approach to students' needs, which contrasts with traditional learning methods (Harjana et al., 2023). Conventional learning

methods in mathematics are often limited because they are less interactive, place too much emphasis on memorization rather than an in-depth understanding of concepts, and cannot adapt to students' individual learning needs, reducing their engagement and motivation (Umbara, 2021).

As the curriculum evolves, teaching methods have naturally adapted to meet the changing needs of students, and one such shift is towards Problem-Based Learning (Dole et al., 2016). Problem-based Learning offers a practical solution by tailoring teaching approaches to students' individual needs and fostering deeper engagement through problems that connect with real-life situations (Silma et al., 2024). This model allows students to explore concepts in depth while honing critical thinking and problem-solving skills (Djonomiarjo, 2020). Moreover, Problem-based Learning encourages students to participate actively in the material, enhancing their numeracy literacy skills. As curriculum developments continue to align with the demands of the modern world, Problem-Based Learning has emerged as a powerful tool to prepare students for future challenges, emphasizing active learning and applying knowledge in real-world contexts (Kwan, 2009). Furthermore, this learning model encourages students' active involvement in the lesson material and develops their numeracy literacy skills.

Based on the initial observation in January 2024 in class XI MIPA-5 at SMA Negeri 3 Kuningan showed that only 8 out of 36 students were able to complete the literacy and numeracy tasks, indicating that the students' numeracy literacy skills are still low. This is based on the results of the evaluation of two-variable linear equation systems; only 22% of students managed to answer correctly. Most students need help acquiring, interpreting, using, and communicating numbers and mathematical symbols to solve practical problems in various contexts. In Problem Based Learning, students can apply their numeracy skills in real-life contexts, such as analyzing data through graphs, tables, or charts and using numbers to make decisions that impact their lives.

Previous research shows a significant effect of using the Problem-Based Learning model on elementary school students' numeracy literacy skills (Rahmah et al., 2023; Pudjiastuti et al., 2024). Problem Based Learning integrated with scaffolding has been shown to enhance junior high school students' numeracy literacy skills in algebraic material (Fathurrohman & Putra, 2024). Furthermore, Susanti et al. (2024) integrated Problem Based Learning with the Teaching at The Right Level approach to improve numeracy literacy skills in Trigonometry. Febiani et al. (2023) have explored Problem Based Learning assisted by Interactive Animation Videos on Numeracy Ability in Spatial Geometry materials. Based on the foundation of previous research, no study has yet integrated Problem-based Learning with a differentiated approach to the topic of systems of linear equations in two variables (SLETV). Therefore, this research aims to investigate how effective the integrated problem-based learning differentiated instruction model is in enhancing students' literacy and numeracy abilities. The expected result is a significant increase in students' numeracy literacy and ability to solve mathematical problems, thanks to the implementation of the Problem Based Learning model, which is integrated with differentiated learning.

## **METHOD**

In this research, the type used is quasi-experimental research (*as if experimental*). The research design used is *one group pretest-posttest design*, namely experimental research carried out on one group chosen randomly. No stability and clarity tests are carried out on the group's condition before being given treatment. The learning carried out in this research uses an experimental approach to test the effectiveness of implementing Problem-based Learning, which is integrated with differentiated learning to improve high school students' literacy and numeracy skills. The subjects in this research were 36 students of class XI MIPA-5 SMAN 3 Kuningan for the 2023/2024 academic year. As for the scheme, *one group pre-test-posttest design* can be seen in Table 1.

Table 1. Scheme *one group pretest-posttest design*

Pre Test	Treatment	Post Test
T <sub>1</sub>	X	T <sub>2</sub>

T<sub>1</sub>: *Pre-test* carried out before being treated

X: *Treatment* (Treatment) using the Problem Based Learning Method

T<sub>2</sub>: *Post Test* implemented after treatment

The research procedures can be seen in Figure 1.

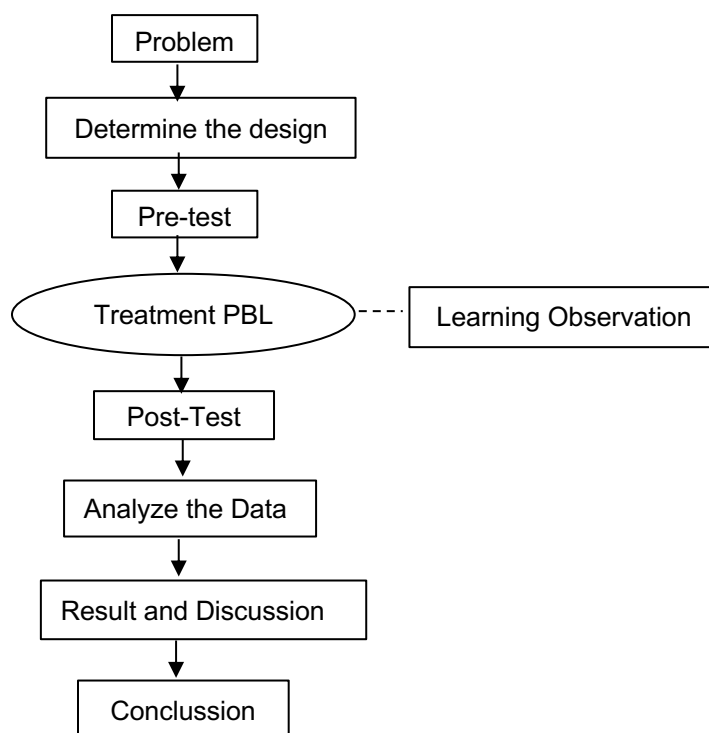


Figure 1. Research Flow

The following describes each research stream, as shown in Figure 1. The main instrument used was a numeracy literacy test of 5 essays to measure students' literacy numeracy abilities in SPLDV. The test was developed based on literacy numeracy indicators and reviewed by experts for content validity. To ensure validity and reliability, the instrument underwent a pilot test involving 32

students who had already received the material. The validity test results for each question, analyzed using Pearson's product-moment correlation with SPSS 26 software, are presented in Table 2.

Table 2. Types of Validity

Number Test	Validity Index	Level of Validity
1	0.57	Medium
2	0.67	High
3	0.54	Medium
4	0.66	High
5	0.66	High

The reliability was measured using Cronbach's Alpha, yielding a coefficient of 0.84, indicating high reliability. The reliability result is presented in Table 3.

Table 3. The Reliability Result

Cronbach's Alpha	N of Items
.84	5

The data analysis was conducted by comparing the pre-test and post-test results. The researcher analyzed the data using the N-Gain test to calculate and compare the improvement before and after the treatment. The N-Gain test allows the researcher to determine whether the improvement is statistically significant.

## RESULT AND DISCUSSION

This research was conducted in January 2024 at SMA Negeri 3 Kuningan. The subjects in this research were 36 students of class XI MIPA-5 at SMAN 3 Kuningan for the 2023/2024 academic year. Students participate in a series of activities that researchers have designed, which consist of filling in questionnaires, following *pre-tests* and *post-tests*, and participating in learning sessions or experiments. Student participation was carried out with clear guidelines and following procedures determined by researchers to obtain valid data. The results of this research consist of filling out the questionnaire, grades *pre-test*, results of learning observations, and grades *post-test*. Table 4 presents the pre-test and post-test scores of 36 students.

Table 4. Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation
pre_test	36	70	10	80	1447	37.83	23.524
post_test	36	55	35	90	2344	75.00	13.779
Valid N (listwise)	36						

Table 4 shows a significant increase in students' average scores after the intervention, as indicated by the rise in the mean from 37.83 to 75.00. Additionally, the distribution of scores became more uniform after the intervention, as shown by the decrease in standard deviation from 23.524 to 13.779. This suggests that the intervention effectively improved students' overall performance and

reduced the variation in their numeracy. These findings are further illustrated in the following diagram, which presents the pre-test and post-test results in Figure 2.

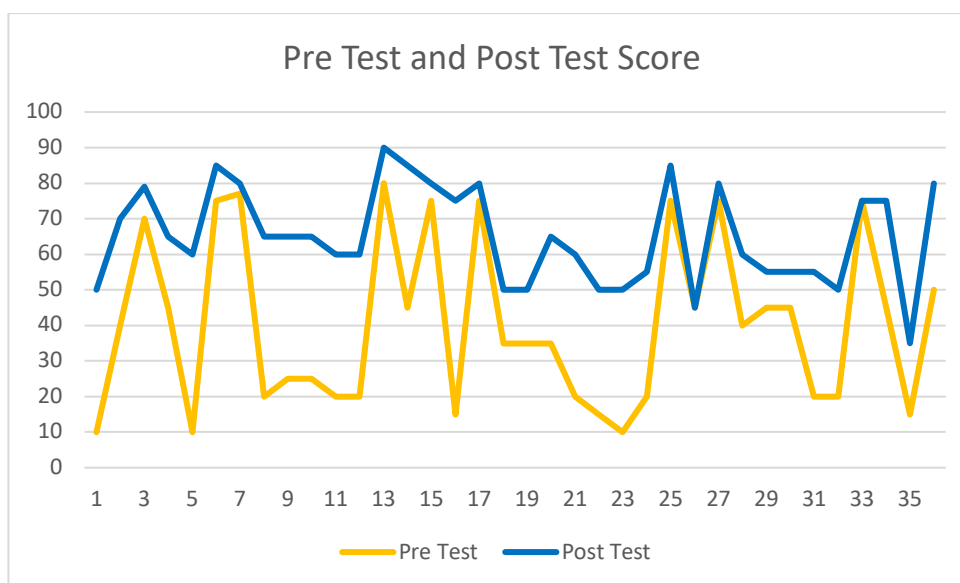


Figure 2. Student Pre-Test and Post-Test Scores

Based on Figure 2, the initial condition of the students before this was carried out *was that* the level of understanding of students' mathematical literacy and numeracy was relatively low. Thirty-six students were tested; only eight scored above 70, with an average score of 37.83. This indicates that most students need higher mathematical literacy and numeracy abilities. As for filling out the student questionnaire in the learning interest questionnaire, the following results were obtained: 12 students had kinesthetic interests and learning styles, 10 were visual, and 14 were auditory. Next, in Graph 1, the results of *pre-test* students after learning using conventional methods show variations in students' initial abilities. A total of 13 students were in the low score category (0-39), 13 other students were in the medium score category (40-69), and 10 students got high scores (70-100). These results indicate that over a third of students were still at a low ability level before the intervention was implemented. Next, the results of *post-test* students can be depicted with the following graph: After implementing the model of *Problem-Based Learning*, which is integrated with differentiated learning, 22 students managed to move up to the medium score category, 14 students reached the high score category, and no students were in the low score category after the intervention.

Based on the research results above, an N-Gain test was carried out on the yield value *pre-test* and *post-tests*. Based on test results, *N-Gain* shows that the increase in student scores is in the medium category, with a score of 0.56, and the percentage increase was 56.05%. This indicates that the intervention positively impacts increasing students' mathematical literacy and numeracy skills. These results show a significant shift towards improving students' mathematical literacy and numeracy skills. The increase in students' mathematical literacy and numeracy skills can also be

seen from the rise in the average score *pre-test* before treatment, which was 37.83, and after treatment, the average value *post-test* of 75.00.

This increase was seen significantly, especially in students' mathematical literacy and numeracy indicators, where students showed better abilities in understanding, interpreting, and analyzing problem-based questions related to mathematical concepts. Before being given *treatment*, students had difficulty linking information from contextual problems with appropriate mathematical models. After implementing integrated Problem Based Learning differentiated learning, students can translate real-world problems into proper mathematical equations or concepts. According to the research results of Hendriyanto et al. (2023), implementing Problem Based Learning learning encourages students to read more, understand, and solve complex problems, thereby improving mathematical literacy skills.

The application of Problem Based Learning shows an increase in students' abilities in numeracy, especially in terms of counting, using basic operations, and applying algebra and geometry concepts (Andri, 2023). After using Problem Based Learning, students are more accurate in doing calculations and can better choose the right numerical strategy to solve problems requiring complex calculations. If Many students make mistakes in the calculation process on a *pre-test* or are mistaken in applying numerical concepts, on a *post-test*, After implementing Problem Based Learning -integrated, differentiated learning, students become more thorough and precise in answering questions.

More than just absorbing information, Problem Based Learning encourages students to develop a deep understanding of the subject matter by applying it in relevant real-life situations. Students learn to connect theory with practice, see relationships between concepts, and use their knowledge to solve problems they may face in the real world (Kinanti & Rejeki, 2023). This process increases their understanding of the subject matter and equips them with essential life skills, such as critical thinking, problem-solving, time management, and research (Uskono et al., 2020).

*Problem-Based Learning* also provides opportunities for students to learn collaboratively. In a Problem Based Learning environment, students often work in small groups, which allows them to share knowledge, discuss ideas, and learn from each other's perspectives. These interactions enrich the learning experience and help students develop interpersonal skills for working in teams (Uskono et al., 2020). Teachers act as facilitators, providing guidance and support when needed but allowing students to take the initiative and be responsible for their learning (Verinsyah & Fitria, 2020).

Problem Based Learning implementation can also be adapted to various scientific disciplines and educational levels, from basic to higher education (Suparman, 2021). Integrating Problem Based Learning integrated, differentiated learning into the curriculum can improve student literacy and numeracy (Pane et al., 2022)., in addition to schools and universities can create dynamic and interactive learning environments that prepare students for real-world challenges and encourage learning throughout life (Otu & Budiningsih, 2023). This approach prepares students for academic exams and their future lives and careers by providing relevant and practical skills that they can apply in various contexts (Ati & Setiawan, 2020). Meanwhile, the steps of PBL can be seen in Table 5.

Table 5. Learning Syntax *Problem-Based Learning*

Learning Phase	Activity	
	Teacher	Student
Preliminary Phase (Initial observation)	<ol style="list-style-type: none"> <li>1. Convey learning objectives to students</li> <li>2. Help students form groups of 4 – 5</li> <li>3. Connect the material to be studied with the material at the previous meeting</li> <li>4. Raises problems related to material topics but linked to life student</li> </ol>	<ol style="list-style-type: none"> <li>1. Listen to the explanation given by the teacher</li> <li>2. Form heterogeneous groups</li> <li>3. Engage in apperception activities (questioning)</li> <li>4. Analyze the initial problem given using life experience (reasoning)</li> </ol>
Problem formulation phase	<ol style="list-style-type: none"> <li>1. Guiding students to formulate the problem</li> <li>2. Explain the method to resolve questions/problems given</li> </ol>	<ol style="list-style-type: none"> <li>1. Formulate a problem statement</li> <li>2. Listen and record problems raised by the teacher (observe and ask questions)</li> <li>3. Listen to the teacher explain how to do discovery activities.</li> </ol>
The phase of formulating strategic alternatives	<ol style="list-style-type: none"> <li>1. Guide students to submit temporary opinions or conjectures based on the problems prepared</li> </ol>	<ol style="list-style-type: none"> <li>1. Write down the hypothesis or temporary guess</li> </ol>
Data collection phase (implementing strategy)	<ol style="list-style-type: none"> <li>1. Direct and guide students to complete the assignments/questions given</li> <li>2. Discussion as a discovery activity</li> <li>3. Ask students to write down their discovery activities on a piece of paper</li> </ol>	<ol style="list-style-type: none"> <li>1. Carrying out experiments based on the given worksheet (trying) while collecting data and analyzing the data found (reasoning)</li> <li>2. Write the experimental results on the worksheet</li> </ol>
Discussion phase	<ol style="list-style-type: none"> <li>1. Guiding students in discussion activities</li> <li>2. Providing corrective information/ reinforcement to students</li> </ol>	<ol style="list-style-type: none"> <li>1. Discuss between groups</li> <li>2. Ask questions if there is material you don't understand (reasoning)</li> </ol>

(Cholilalah, Rois Arifin, 2021).

Overall, test results *N-Gain*, which is in the medium category, and an increase in students' mathematical literacy and numeracy indicators show that applying Problem Based Learning with differentiated learning effectively improves students' abilities in understanding and solving mathematical problems. This proves that Problem Based Learning not only helps students master the material but also strengthens critical thinking skills, literacy and numeracy, and problem-solving skills, which are very important in education.

The research results show that implementing *Problem-Based Learning* integrated with differentiated learning effectively improves students' mathematical literacy and numeracy skills in solving daily problems related to Systems of Linear Equations in Two Variables (SLETV). This learning increases students' understanding of SLETV concepts and helps them develop analytical skills, problem-solving, and practical applications in real situations. Further discussion emphasizes

the importance of this approach in supporting students' success in understanding and applying mathematics in the context of everyday life, as well as providing a basis for developing learning strategies that are more inclusive and responsive to students' individual needs (Fitra, 2022).

## CONCLUSION

The Problem-Based Learning model integrated with the Differentiated Instruction approach is an effective strategy for enhancing high school students' literacy and numeracy skills. Problem Based Learning emphasizes problem-based learning, encouraging students to explore, analyze, and solve problems independently or collaboratively. Meanwhile, Differentiated Instruction ensures that learning strategies are tailored to students' needs, readiness, interests, and learning profiles. Integrating these two approaches creates a more inclusive and adaptive learning environment, allowing students to develop according to their potential. In numeracy, Problem Based Learning involves solving mathematical problems such as data analysis, calculations, and number-based decision-making, which can be adjusted to students' comprehension levels through differentiation strategies.

Additionally, this approach enhances student engagement and motivation as they learn within their zone of proximal development, which aligns with Vygotsky's theory. However, this study has several limitations. Variations in the implementation of differentiation and the design of problems in Problem Based Learning may affect learning outcomes, requiring further research to identify the most influential factors. Moreover, this study has not explicitly explored the challenges teachers may face in implementing this approach in diverse classroom settings.

For future research, empirical studies are recommended to examine the effectiveness of integrating Problem Based Learning and Differentiated Instruction in real-world contexts through experiments or case studies across various levels and subjects. Future studies could also investigate the impact of this approach on student groups with specific characteristics, such as students with different learning styles or those with learning difficulties. Additionally, a more systematic implementation model should be developed, including guidelines for teachers to apply Problem Based Learning integrated with differentiation effectively.

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