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Integrated PBL Differentiated Instruction: An Effort to Improve Students' Literacy and Numeracy Skills

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Abstract. Mathematics, as a subject that is well known and studied by elementary school to middle school students, aims to ensure that students can understand and master it well to experience its benefits in everyday life. One of the mathematical skills that students must have is literacy and numeracy skills. Students' mathematical literacy and numeracy abilities are important components of measuring students' cognitive abilities. However, based on the results of initial observations at SMA Negeri 3 Kuningan, in reality, students' mathematical literacy and numeracy skills are still low, as can be seen from their difficulties in understanding, using, and communicating mathematical numbers and symbols, including analyzing data from graphs, tables, and diagrams for retrieval. This research investigates how the method is implemented: problem-based learning (PBL), integrated with differentiated learning, can influence students' mathematical literacy, numeracy skills, and ability to solve mathematical problems. The research method uses an experimental approach. The research results were obtained from test results N-Gain, with scores of 0.56 (medium category) and an increase percentage of 56.05%. This increase can be seen significantly in students' mathematical literacy and numeracy indicators. Students show better abilities in understanding, interpreting, and analyzing problem-based questions related to mathematical concepts. Overall, there is an increase in students' mathematical literacy and numeracy skills.

Keywords: PBL, differentiated, literacy, numeracy, effective

I. INTRODUCTION

Mastery of mathematics is very important for everyone. Mathematics learning is taught at all levels of education, from elementary to high school, to achieve national education goals. In this era of globalization, mathematics is becoming increasingly vital in preparing the younger generation to face the challenges of the modern era (Pangaribuan & Ginting, 2022). Besides that, mathematics is a mandatory subject in the curriculum at all levels of formal education, from elementary school to university.

Numeracy literacy is closely related to mathematics, and literacy skills in mathematics are key to academic success (Fajri et al., 2022). Mathematical literacy is understanding and applying mathematical concepts, while mathematical numeracy is using numbers and mathematical operations to solve problems (Nolly 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 effective in training critical thinking, so students receive more information without deep understanding. (Mastuti et al., 2023).

Suppose students need literacy and numeracy. In that case, it is necessary to carry out needs assessments, implement special learning and teacher training, use interactive media, and involve parents and regular evaluations to monitor and adjust learning strategies/methods. (Alfiah & Zulfitria, 2024).

Traditional 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 are unable to adapt to student's individual learning needs, thereby reducing their engagement and motivation (Umbara, 2021). Overcoming the limitations of traditional learning, differentiated learning and Project-Based Learning (PBL) offer effective solutions by adapting teaching methods according to students' needs and increasing their involvement through projects that are relevant to real life. This approach helps understand concepts in depth and develops critical thinking and problem-solving skills (Djonomiarjo, 2020). Furthermore, this learning model encourages students' active involvement in the lesson material and develops their numeracy literacy skills.

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Initial observations in January 2024 in class: Most students need help in acquiring, interpreting, using, and communicating numbers and mathematical symbols to solve practical problems in various life contexts. They also need help analyzing information from graphs, tables, and charts to make decisions. This is based on the results of the evaluation of two-variable linear equation systems; only 22% of students managed to answer correctly. Based on this, this research aims to investigate how implemented Problem-Based Learning (PBL), which is integrated with differentiated learning, can influence students' abilities in numeracy literacy and their ability to solve mathematical problems. The expected result is a significant increase in students' numeracy literacy and ability to solve mathematical problems, thanks to implementing the PBL model, which is integrated with differentiated learning.

II. METHODS

In this research, the type used is quasi-experimental research (as if experimental). Namely, experimental research was carried out on only one group called the experimental group; there is no comparison group or control group (Suharsimi, 2020). 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. Research design one group pretest design This is measured using a pretest done before being treated and a posttest carried out after being given treatment for each lesson. The learning carried out in this research uses an experimental approach to test the effectiveness of implementing Problem-based Learning (PBL), 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 below:

Table 1. Scheme one group pretest-posttest design

Pre Test	Treatment	Post Test
T_1	X	T_2

T_1: Pre-test carried out before being treated

X: Treatment (Treatment) using the PBL Method

T_2: Post Test implemented after treatment

The research procedures can be seen in the research flow below:

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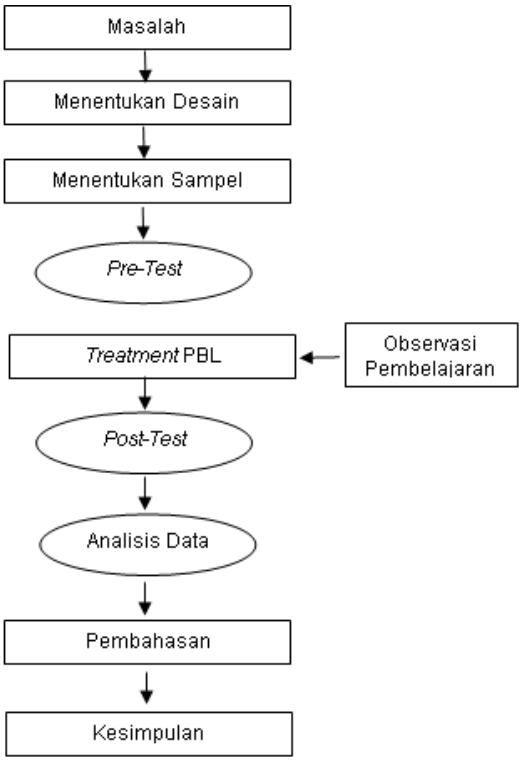

Figure 1. Research Flow

The following describes each research stream, as shown in Figure 1 above. The research started by finding problems. In the initial learning observations by researchers in January 2024, 8 out of 36 students in class interpreted, used, and communicated numbers and mathematical symbols to solve practical problems in various contexts of daily life. From these observations, students' mathematical literacy and numeracy abilities are likely low.

Next, in the second stage, the research design is determined; the selected research design is a group pretest. This is measured using a pretest, done before being treated, and a posttest, carried out after being given treatment for each lesson. Learning carried out before being given treatment uses conventional learning, and when being given treatment, it uses learning with a learning approach Problem-Based Learning (PBL) integrated differentiated learning. At the end of conventional learning, students are given a pre-test, which is done to measure students' initial mathematical literacy and numeracy abilities. After that, the learning process uses methods such as problem-based learning (PBL), which is integrated with differentiated learning, and at the end of the learning, it is carried out post-test.

In the third stage, the research sample was determined, and the sample was taken from all students in class XI MIPA-5 at SMA Negeri 3 Kuningan, totaling 36 students. Determining this sample is important to ensure that the research obtains representative results. Class

The fourth stage is a pre-test to measure students' initial mathematical literacy and numeracy abilities after conventional learning. Pre-Test This aims to measure students' initial literacy and numeracy skills. Pre-tests provide an overview of the student's knowledge or skills before intervention implementation. Results Pre-Test This will be a benchmark to compare the results with post-tests after treatment is given. Besides that, the pre-test also functions to find out whether there are significant differences in students' initial abilities between one another.

The fifth stage is doing treatment with the application of integrated PBL with differentiated learning (Treatment). This stage is the core of the research process. Researchers apply Problem-Based Learning (PBL), integrated with differentiated learning in learning with material on Systems of Linear Equations in Two Variables (SPLDV). PBL is designed to improve students' critical thinking and problem-solving abilities. At the same time, differentiated learning aims to adapt teaching strategies according to each student's needs, interests, and ability levels. Before learning begins, students are also asked to fill out a questionnaire regarding their learning interests, which will be used to see how the intervention affects students' motivation and interest in learning. Once the learning is complete, it is carried out to measure changes or improvements in students' mathematical literacy and numeracy abilities after the integrated PBL treatment is implemented.

The sixth stage is observing the learning process, which ensures the implementation of integrated PBL goes according to plan and identifies challenges that arise. During the implementation of the intervention, regular observations were made

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to ensure that the PBL model integrated with differentiated learning was implemented according to plan. At this stage, researchers can identify problems or challenges that may arise, such as students having difficulty understanding new methods or adjustments in implementing differentiation. This observation is important to maintain the intervention implementation quality and ensure that all procedures are carried out properly. Researchers can immediately make improvements or adjustments if students or teachers face difficulties or obstacles.

The seventh stage involves a post-test. This was done to measure the increase in students' mathematical literacy and numeracy skills after the intervention. Post-tests were used to measure the extent to which students' literacy and numeracy skills increased after receiving integrated PBL treatment. Post-Tes is also a tool for identifying areas that still need improvement in the learning process.

The eighth stage continues with data analysis. Data analysis is carried out by comparing the results pre-test and results post-test. Researchers carried out data analysis using tests N-Gain to calculate and compare the improvements that occur before and after being given treatment. Test N-Gain allows researchers to see whether or not there is a statistically significant increase.

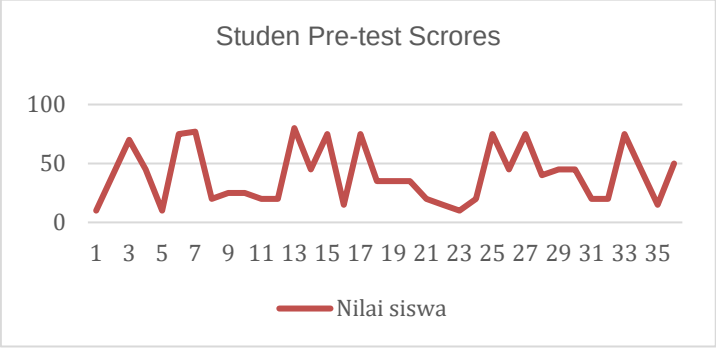
The ninth stage is discussion. After data analysis, a discussion is carried out. The discussion only looks at whether or not there is an increase in results pre-test compared with the results post-test. The researcher did not test the research instruments, so no other statistical tests were used in this research.

The tenth stage is discussion; in the discussion, the researcher only focuses on the test results N-Gain. Suppose the results of the data analysis show significant differences between the pre-test and the post-test results. In that case, it can be concluded that the application of the differentiated integrated PBL method has a positive impact on students' abilities, and it can also be concluded that the intervention provided effectively improves students' mathematical literacy and numeracy skills. The conclusions of this research will also be the basis for providing recommendations for further research or implementation of the same learning method in other classes

III. RESULTS 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. Below are presented the value results of pre-test Conventional learning are shown in Graph 1 as follows:

I.



Graph 1. Student Pre-Test Scores

Based on the graphic analysis, 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 8 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. The student learning style grouping table is in Appendix 1, and the student learning interest questionnaire is in Appendix 2. 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

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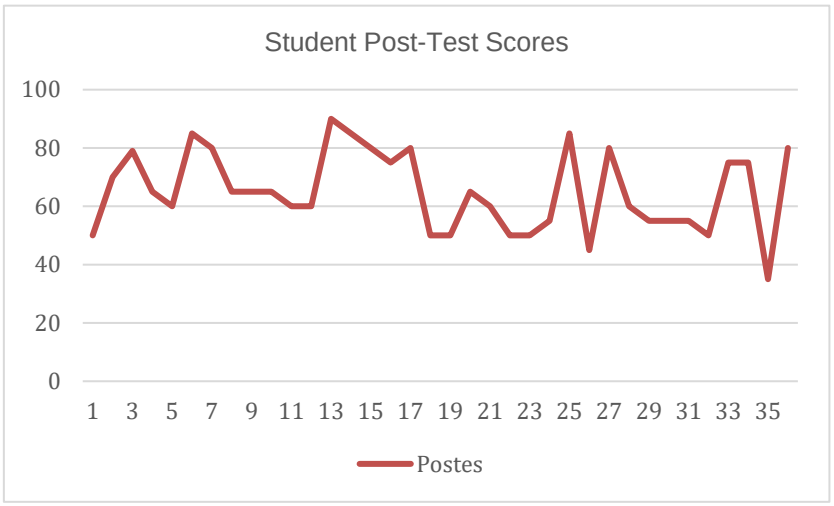
at a low ability level before the intervention was implemented. Next, the results of post-test students can be depicted with the following graph:



Graph 2. Results Value Post-Test Student Learning

After implementing the model of Problem-Based Learning (PBL), 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, with an average score of 75.00.

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 shows that the intervention positively impacts increasing students' mathematical literacy and numeracy skills. These results show a significant shift towards increasing students' mathematical literacy and numeracy skills. The increase in students' mathematical literacy and numeracy skills can also be seen from the increase in the average score pre-test before treatment, which was 37.83, and after treatment, the average value post-test of 75.00. Details of score calculation N-Gain can be seen in attachment 3.

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 PBL differentiated learning, students can translate real-world problems into appropriate mathematical equations or concepts. According to the research results of Hendriyanto et al. (2023), implementing PBL learning encourages students to read more, understand, and solve complex problems, thereby improving mathematical literacy skills.

The application of PBL 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 PBL, students are more accurate in doing calculations and can better choose the right numerical strategy to solve problems requiring complex calculations. If, on a pre-test, Many students make mistakes in the calculation process or are mistaken in applying numerical concepts, on a post-test, After implementing PBL-integrated differentiated learning, students became more thorough and precise in answering questions.

More than just absorbing information, PBL 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 apply 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 important life skills, such as critical thinking abilities, problem-solving, time management, and research skills (Uskono et al., 2020).

Problem-Based Learning (PBL) also provides opportunities for students to learn collaboratively. In a PBL 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).

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PBL implementation can also be adapted to various scientific disciplines and educational levels, from basic to higher education (Suparman, 2021). Integrating PBL 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). The following are the learning syntax Problem-Based Learning as follows:

Table 1. Learning Syntax Problem-Based Learning

Learning Phase	**Activity**	
	Teacher	**Student**
Preliminary Phase (Initial observation)	1.Convey learning objectives to students 2. Help students form groups of 4 – 5 3.Connect the material to be studied with the material at the previous meeting 4. Raises problems related to material topics but linked to life student	1. Listen to the explanation given by the teacher 2. Form heterogeneous groups 3. Engage in apperception activities (questioning) 4. Analyze the initial problem given using life experience (reasoning)
Problem formulation phase	1. Guiding students to formulate the problem 2. Explain the method to resolve questions/problems given	1. Formulate a problem statement 2. Listen and record problems raised by the teacher (observe and ask questions) 3. Listen to the teacher explain how to do discovery activities.
The phase of formulating strategic alternatives	1. Guide students to submit temporary opinions or conjectures based on the problems prepared	1. Write down the hypothesis or temporary guess
Data collection phase (implementing strategy)	1. Direct and guide students to complete the assignments/ questions given 2. Discussion as a discovery activity 3. Ask students to write down their discovery activities on a piece of paper	1. Carrying out experiments based on the given worksheet (trying) while collecting data and analyzing the data found (reasoning) 2. Write the experimental results on the worksheet
Discussion phase	1. Guiding students in discussion activities 2. Providing corrective information/ reinforcement to students	1. Discuss between groups 2. Ask questions if there is material you don't understand (reasoning)

(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 PBL with differentiated learning effectively improves students' abilities in understanding and solving mathematical problems. This proves that PBL not only helps students master the material but also strengthens critical thinking skills, improves literacy and numeracy, and improves problem-solving skills, which are very important in education.

The research results show that implementing Problem-Based Learning (PBL) 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 (SPLDV). This learning increases students' understanding of SPLDV 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).

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IV. CONCLUSIONS

Based on the research that has been carried out, it can be concluded that implementation of Problem-Based Learning (PBL), which is integrated with differentiated learning, significantly improves students' numeracy literacy skills, especially in the material on Systems of Linear Equations in Two Variables (SPLDV). This method not only deepens students' understanding of mathematical concepts but also develops their critical and analytical thinking skills. Therefore, it is recommended that teachers adopt and adapt a PBL approach that is integrated with differentiated learning in mathematics teaching to create a more inclusive and effective learning environment. This approach also supports developing numeracy skills essential for everyday life, thereby providing wider benefits for students.

Suggestions that can be made based on this research for developing learning in the future include the implementation of Problem-Based Learning (PBL), which is integrated with differentiated learning by mathematics teachers, especially in the material Systems of Linear Equations in Two Variables (SPLDV). This approach allows teachers to design contextual learning activities to help students solve real

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