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THE EFFECTIVENESS OF IMPLEMENTING A DIFFERENTIATED INSTRUCTION TEACHING MODULE THROUGH A PROBLEM-BASED LEARNING MODEL IN IMPROVING STUDENTS' PROBLEM-SOLVING SKILLS

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Abstract

This study aims to examine the effectiveness of a differentiated learning module based on Problem-Based Learning (PBL) in improving students' mathematical problem-solving skills on the topic of Systems of Two-Variable Linear Equations (SPLDV). Using a quantitative approach with a pretest–posttest control group design, the research involved an experimental class that received instruction using the differentiated PBL-based module and a control class that followed conventional learning. Primary data were obtained from pretest and posttest scores, while secondary data consisted of expert validations and student response questionnaires. The results showed that the module met the feasibility criteria based on evaluations from material and media experts. Statistical analysis indicated that the experimental class demonstrated significantly higher improvement than the control class. The independent t-test confirmed a significant difference in posttest scores, the classical mastery level exceeded the 75% threshold, and the N-Gain score fell into the high category. These findings suggest that the differentiated PBL-based learning module is effective and suitable for enhancing students' mathematical problem-solving abilities.

Keywords: differentiated instruction, problem-based learning, mathematical problem-solving

Abstrak

Penelitian ini bertujuan untuk menguji efektivitas modul ajar pembelajaran berdiferensiasi berbasis Problem Based Learning (PBL) dalam meningkatkan kemampuan pemecahan masalah matematis siswa pada materi Sistem Persamaan Linear Dua Variabel (SPLDV). Penelitian menggunakan pendekatan kuantitatif dengan desain pretest–posttest control group. Sampel penelitian terdiri atas kelas eksperimen yang menggunakan modul ajar berdiferensiasi berbasis PBL dan kelas kontrol yang mengikuti pembelajaran konvensional. Data primer diperoleh dari skor pretest dan posttest, sedangkan data sekunder berasal dari hasil validasi ahli dan angket respons siswa. Hasil penelitian menunjukkan bahwa modul ajar memenuhi kriteria kelayakan berdasarkan penilaian ahli materi dan ahli media. Analisis efektivitas memperlihatkan bahwa peningkatan kemampuan pemecahan masalah pada kelas eksperimen lebih tinggi dibandingkan kelas kontrol. Uji independent t-test menunjukkan perbedaan signifikan antara kedua kelas, ketuntasan klasikal kelas eksperimen melampaui batas 75%, dan nilai N-Gain berada pada kategori tinggi. Dengan demikian, modul ajar pembelajaran berdiferensiasi berbasis PBL efektif digunakan untuk meningkatkan kemampuan pemecahan masalah matematis siswa.

Kata kunci: pembelajaran berdiferensiasi, Pembelajaran berbasis masalah, pemecahan masalah matematika

INTRODUCTION

Mathematics learning is a process involving the interrelation of various instructional components to help students understand concepts, develop thinking skills, and solve problems through their own activities and experiences. Through mathematics, students can actively develop a range of abilities, including reasoning, logic, creative thinking, mathematical communication, and problem-solving skills (Murtianto, 2013). According to How to Differentiate Instruction by Carol Ann Tomlinson (2003), differentiated instruction

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emphasizes individual differences by considering students' readiness, interests, and learning profiles. It also enables teachers to modify learning objectives, processes, products, and the learning environment to align with each learner's characteristics. The implementation of this approach provides students with opportunities to learn according to their abilities and interests, while simultaneously supporting the development of the Pancasila Student Profile in the Merdeka Curriculum (Martianto et al., 2021).

In mathematics learning, every problem inherently has a solution; therefore, problem-solving ability becomes an essential component of the mathematics curriculum (Pratiwi, 2024). Moreover, in the rapid development of the twenty-first century, problem-solving skills have become a critical competency for achieving success in both personal and professional domains, serving as a foundational element of twenty-first-century readiness (Adeoye & Jimoh, 2023; Rusmin & Misrahayu, 2024). Considering the essential role of problem-solving in mathematics, these skills must be continuously developed and placed as a central focus in instructional practices.

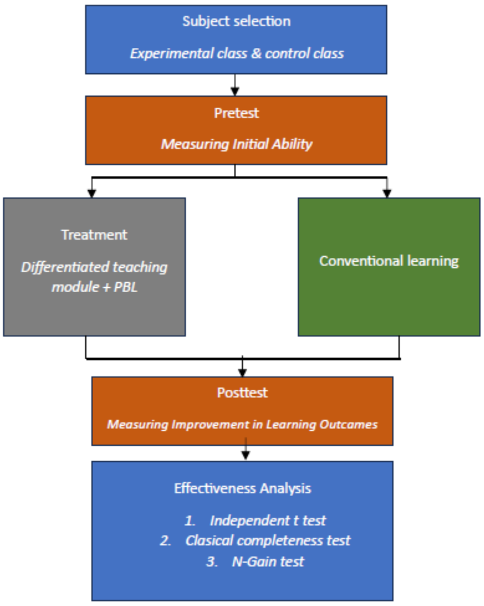
Although problem-solving skills play a highly important role, field evidence shows that students' mathematical problem-solving abilities remain relatively low (Pratiwi, 2024; Rajani et al., 2025). In efforts to improve students' problem-solving skills, teachers must be able to differentiate classroom instruction. Each student inherently differs in terms of ability, interests, cultural background, and learning style. One instructional strategy capable of addressing the learning needs of students with diverse abilities is differentiated teaching (Pratiwi, 2024; Rajani et al., 2025). Therefore, teachers must be able to master differentiated instruction to meet students' needs, remediate or accelerate instruction, and provide meaningful learning and growth opportunities for all learners (Andini et al., 2016).

Differentiated instruction is an approach that allows teachers to design strategies that address the needs of each student (Goyibova et al., 2025; Mariyatul et al., 2024). Fitriah and Bisri (2023) assert that differentiated instruction is a learning approach grounded in students' varying levels of readiness, learning profiles, and interests. Based on students' characteristics, Tomlinson et al. (2003) explain that differentiation can be implemented through three elements: (1) Readiness, when the tasks assigned by the teacher align with students' ability levels; (2) Learning profile, when the tasks encourage students to learn in ways that suit their preferred learning styles; and (3) Interest, when the tasks stimulate students' curiosity and enthusiasm for learning.

Referring to the definition of differentiated instruction, the implementation of the Problem-Based Learning (PBL) model serves as a subsequent step that enables students to develop their potential through problem-solving activities. The PBL model is designed to facilitate student learning by engaging them in solving real-life problems through discussion, exploration, and collaboration (Hendarwati et al., 2021; Wikara et al., 2022). Aligned with the integration of these two approaches, and considering the high urgency of enhancing problem-solving abilities in mathematics education, this study aims to examine the effectiveness of implementing a teaching module developed based on differentiated instruction and integrated with the Problem-Based Learning (PBL) model. The resulting teaching module is applied to mathematical topics that require problem-solving competence, and it is expected to contribute to more adaptive, contextual, and student-centered instructional strategies.

METHODS

This study employed a quantitative research method with a quasi-experimental approach. The research utilized a pretest–posttest control group design, in which two groups of students—an experimental group and a control group—were each administered a pretest. The experimental group then received treatment using a differentiated instruction teaching module integrated with the Problem-Based Learning (PBL) model, whereas the control group received conventional instruction. After the treatment, both groups were administered a posttest to measure the extent of improvement in students' mathematical problem-solving abilities. The research procedure is illustrated as follows:



Picture 1. Research flow

This research was conducted at SMP 4 Muhammadiyah Semarang, located in Salamanmloyo Village, West Semarang District, Semarang City, Central Java. The study was carried out during the even semester of the 2025/2026 academic year, specifically from January 5, 2026 to February 8, 2026. The population of this study included all eighth-grade students at SMP 4 Muhammadiyah Semarang. The quantitative sample was selected using a random cluster sampling method by choosing two classes, one as the experimental group and one as the control group. The sample consisted of two classes: Class VIII A as the control group and Class VIII B as the experimental group.

The data in this study consist of quantitative data divided into two types. Primary data were obtained from the pretest and posttest scores measuring students' mathematical problem-solving abilities in both the experimental and control groups. Secondary data included the results of the teaching module validation by experts and students' response questionnaires, which served as supporting data in evaluating the feasibility and practicality of the differentiated instruction teaching module.

Before the intervention was implemented, an initial assessment was conducted to measure students' critical thinking abilities. The purpose of this assessment was to understand the fundamental elements of students' problem-solving skills. Various frameworks can be used to identify indicators of problem-solving ability. According to Polya (1945), these indicators include four stages of problem-solving:

1. Understanding the problem
2. Devising a plan
3. Carrying out the plan
4. Looking back

The following are the test instruments used in this study

Tabel 1. Instrument Questions

No	Questions
1	Three years ago, Uncle Indra was 21 years older than Indra. Four years from now, Uncle Indra’s age will be three times Indra’s age. If the age of Indra’s older sibling is the average of Uncle Indra’s age and Indra’s age, how old is Indra’s older sibling?”
2	Three friends Andi, Budi, and Citra use an online transportation service. The total transportation cost paid by Andi and Budi is Rp28,000. Andi’s transportation cost is Rp4,000 more expensive than Budi’s. Andi’s cost is also twice the cost paid by Citra. Construct a mathematical model (a system of linear equations in two variables/SPLDV) based on the information above, and determine the transportation costs paid by Andi, Budi, and Citra.
3	A store sells 2 notebooks and 3 pencils for Rp15,500. On the following day, the store offers a discount of Rp500 for each notebook and Rp200 for each pencil. During the promotion day, a customer buys 3 notebooks and 1 pencil, resulting in a total cost of Rp12,800. What is the price of one notebook and one pencil before the discount?

4 A clothing store sells jackets and T-shirts at certain prices.

- Without discounts, 2 jackets and 3 T-shirts are sold for Rp410,000.
- On a promotion day, the store offers a discount of Rp20,000 for each jacket and Rp10,000 for each T-shirt.
- After the discount, 3 jackets and 1 T-shirt are sold for Rp370,000.
- The store owner claims that the discount policy is appropriate and does not cause the store to incur losses.

Determine the price of one jacket and one T-shirt before the discount, and then analyze whether the store owner’s statement is correct based on your calculations.

5 The ages of the mother, Uncle Tino, and Putri have the following relationships:

- The sum of the mother’s age and Uncle Tino’s age is 50 years.
- The mother’s age is 8 years older than three times Putri’s age.
- The difference between the mother’s age and Uncle Tino’s age is 14 years.

Construct the mathematical model based on this information and determine each person’s age.

The independent t-test, classical mastery analysis, and N-Gain test were used in this study to evaluate the validity of the null hypothesis and to determine the effectiveness of the applied treatment. Prior to conducting the independent t-test, prerequisite tests—namely the normality test and homogeneity test—were performed to ensure that the data met the fundamental assumptions of parametric statistical analysis. The independent t-test was employed to determine whether there was a significant difference between the experimental and control groups. The classical mastery analysis was used to assess the proportion of students who achieved the minimum mastery criterion of 75%, while the N-Gain test was applied to measure the improvement in students’ problem-solving abilities before and after the implementation of the differentiated instruction teaching module.

RESULTS AND DISCUSSION

The results of the media feasibility assessment show that the teaching module received scores categorized as feasible to highly feasible from both validators. The evaluation conducted by the first validator indicated feasibility scores of 80% for the module size, 86% for the cover design, and 76% for the content design. Meanwhile, the second validator provided higher feasibility percentages, namely 100% for the module size, 94% for the cover design, and 100% for the content design. These findings align with the validity criteria proposed by Plomp (2007), which state that a development product is considered valid when it has undergone expert judgment and demonstrates internal consistency in terms of design, structure, and content. Therefore, the validation results indicate that the developed teaching module meets both content and construct validity criteria, making it appropriate for instructional use.

The implementation of the learning process was carried out after the differentiated teaching module for the SPLDV topic was declared feasible for use. Students were first grouped based on ability levels (TaRL) into slow learners, normal learners, and fast learners using initial assessment data provided by the teacher. After the classification, the class was organized into heterogeneous learning groups consisting of 5–6 students in each group, combining all three ability levels to promote collaboration and mutual support during learning activities.

The learning process took place over three sessions using the Problem-Based Learning model supported by student worksheets (LKPD). Each worksheet contained three types of problems aligned with students' ability levels and included differentiated scaffolding: extensive scaffolding for slow learners, limited scaffolding for normal learners, and no scaffolding for fast learners. All groups completed the worksheets and presented their work in front of the class during each session. After the entire learning sequence was completed, students were administered a posttest to measure their improvement in understanding the SPLDV material after participating in the differentiated instruction.

After implementing differentiated instruction using the Problem-Based Learning model over three instructional sessions, the next step was to conduct statistical analyses to determine the effectiveness of the learning intervention. The analyses included testing the difference in mean learning outcomes, assessing classical mastery, and measuring the N-Gain to evaluate improvements in students' problem-solving abilities. These three analyses were employed to provide a comprehensive overview of the impact of differentiated instruction on students' learning outcomes in the SPLDV topic. The results of the statistical analyses are presented as follows.

1. **Independent t-Test (Mean Difference Test)**

   This test aims to determine the difference between the mean problem-solving abilities of students who received differentiated instruction and those who received conventional instruction. The independent t-test was used as the statistical procedure to compare the two groups. An independent t-test is a statistical method used to determine whether there is a statistically significant difference between the means of two independent sample groups. The hypotheses tested in this study are as follows:

$H_0: \mu_1 \leq \mu_2$	:	The mean problem-solving test score of students who received differentiated instruction is less than or equal to the mean problem-solving test score of students who received conventional instruction
$H_1: \mu_1 > \mu_2$	:	The mean problem-solving ability of students who received differentiated instruction is higher than the mean problem-solving test score of students who received conventional instruction

   Average difference test using excel with criteria rejected if the score $H_0 t_{hitung} > t_{tabel}$. The test of average difference using excel yields the output in table 2. The mean difference test was conducted using Excel, with the criterion that H_0 is rejected if the t-statistic (t_{count}) is greater than the t-table value ($t_{count} > t_{table}$). The results of the mean difference test performed in Excel are presented in Table 2 below.

Table 2. *Independent t test* Output

t-Test: Two-Sample Assuming Unequal Variances

	Posttest eksperimen	*Posttest kontrol*
Mean	83,40740741	46,8
Variance	14,48148148	62,33333333
Observations	27	25
Hypothesized Mean Difference	0	
Df	34	
t Stat	21,03150105	
P(T<=t) one-tail	2,28E-21	
t Critical one-tail	1,690924255	
P(T<=t) two-tail	**4,56E-21**	
t Critical two-tail	**2,032244509**	

Based on the table above, it is found that ($t_{count} = 4{,}56 > t_{table} = 2{,}03$), therefore, H_0 is rejected and H_1 is accepted. This indicates that the average problem-solving ability of students taught with differentiated learning is significantly higher than that of students taught with conventional learning.

2. Classical Mastery Test

A one tailed proportion test was used to determine whether the percentage of student learning mastery reaching the minimum proficiency criterion (KKM 75) in the experimental class exceeds the 75% threshold. The hypotheses to be tested are formulated as follows

$H_0: \pi \leq 75\%$	The proportion of students reaching the minimum proficiency criterion (KKM) after being taught with differentiated learning is less than or equal to 75%
$H_1: \pi > 75\%$	The proportion of students reaching the minimum proficiency criterion (KKM) after being taught with differentiated learning is greater than 75%.

The classical mastery test was conducted with the criterion that H_0 is rejected if the z-statistic is greater than the z-table value ($z_{count} > z_{table}$). The results of the classical mastery test performed using Excel are presented in Table 3 below:

Table 3. Proportion Test Results

Experimental Class Post-test	**Z Test**		
	z_{count}	α	z_{table}
	2,111	0,05	1,645

Based on Table 4.19, it is found that z_{count}= *2,111* > z_{table}= *1,645* which indicates that H_0 is rejected. Consequently, it can be concluded that the proportion of student learning mastery taught using differentiated learning exceeds the 75% threshold.

3. N-Gain test

The N-Gain test was used to evaluate the improvement in students' problem-solving abilities before and after the treatment. The N-Gain test analysis, performed using SPSS 26.0, yielded the output presented in Table 4. below:

Table 4. N-Gain Test Results

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
ngain_score	27	.50	1.00	.7237	.11559
Valid N (listwise)	27				

Based on the SPSS output in Table 4.20, the mean N-Gain score is 0.7237, which falls into the "high" category. This indicates that the improvement in students' problem-solving abilities through the differentiated learning model is classified as high.

The results of the study indicate that the implementation of differentiated instruction using the Problem-Based Learning model supported by student worksheets (LKPD) has a significant positive effect on students' problem-solving abilities in the SPLDV topic. Based on the independent t-test, the mean score of the experimental group was significantly higher than that of the control group. The calculated t-value, which far exceeded the critical t-value, suggests that differentiated instruction is more effective than conventional instruction. This finding aligns with differentiation theory, which states that providing learning support aligned with students' readiness levels can enhance conceptual understanding and the quality of problem solving.

In addition, the results of the classical mastery analysis show that the proportion of students in the experimental group who achieved the minimum mastery criterion exceeded 75%, surpassing the required threshold. The calculated z-value, which was greater than the critical z-value, confirms that differentiated instruction not only improves average performance but also increases the overall proportion of students who achieve mastery. This demonstrates that a differentiated approach is capable of accommodating diverse learning needs, enabling most students to reach the expected minimum standard.

These findings are further supported by the N-Gain results, which indicate that the improvement in students' problem-solving abilities falls within the high category, with an average score of 0.7237. This improvement reflects the role of differentiated instruction in strengthening conceptual mastery through proportional scaffolding. The use of tiered tasks in the LKPD, combined with heterogeneous group formation, also provided opportunities for students to support one another and deepen their thinking processes through discussion.

Based on the independent t-test, classical mastery analysis, and N-Gain scores, the application of the differentiated teaching module was effective in improving students' problem-solving abilities. The effectiveness of differentiated instruction is consistent with findings from previous studies by Lukitawanti et al. (2024), Mulbar et al. (2017), Pratiwi (2024), Rajani et al. (2025), and Supriatna et al. (2024), all of which reported that differentiated instruction is effective and has a positive impact on problem-solving skills. This effectiveness can be attributed to the combination of differentiated instruction and the PBL model, which enhances student engagement, promotes critical thinking, and strengthens problem-solving abilities (Supriatna et al., 2024).

This substantial improvement reflects the characteristics of differentiation, which allows students to learn according to their cognitive development levels, combined with the features of PBL that require students to solve authentic problems. This is consistent with findings by Pratiwi (2024) and Rajani et al. (2025), who found that combining PBL with differentiated instruction significantly improves higher-order thinking skills and concept retention. A study by Putri (2024) also demonstrated that PBL integrated with differentiated instruction enhances mathematical problem-solving skills, as students are given opportunities to explore strategies that best match their learning styles

CONCLUSION

Based on the implementation of the differentiated instruction teaching module using the problem-based learning model, the experimental class demonstrated a significantly higher improvement in learning outcomes compared to the control class. This is evident from the higher average test scores achieved by students in the experimental class. In addition, the results of the classical mastery test show that more than 75% of students in the experimental class reached the minimum mastery criteria, indicating that the mastery standard was successfully met. These findings are further supported by the N-Gain analysis, which falls into the high category, signifying that the improvement in students' mathematical problem-solving abilities occurred optimally. Overall, these results indicate that the application of the differentiated instruction teaching module has a more positive impact than conventional instruction. The module not only enhances students' learning outcomes but also effectively promotes the development of their mathematical problem-solving skills through an adaptive approach that aligns with individual learning needs.

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