



SMART-KU Module Based on Local Wisdom in Problem-Based Learning on Mathematical Problem-Solving Ability of Elementary School Students: An Experimental Study

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Abstract

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Mathematical problem-solving ability is an important ability for students to master, but it is often not facilitated due to the lack of use of adequate teaching materials and learning models. This study aims to examine the effectiveness of SMART-KU local wisdom-based module in Problem-Based Learning on students' mathematical problem-solving ability. Using a quantitative method of quasi-experimental design, which specifically takes a non-equivalent control group design, with a total sample of 32 fifth-grade students of SDN 1 Mijen in the experimental class and control class, and data analysis through paired sample t-test, independent sample t-test, and N-Gain score test. The results showed that: (1) through paired sample t-test, there is a significant average difference in students' mathematical problem solving ability before and after treatment, both in experimental (Sig. (2-tailed) = 0.000 (≤ 0.05)) and control classes (Sig. (2-tailed) = 0.000 (≤ 0.05)), (2) through independent t-test, there is a significant average difference in students' mathematical problem solving ability between experimental and control classes (Sig. (2-tailed) = 0.000 (≤ 0.05)), and (3) through N-Gain test, students' mathematical problem solving ability in experimental classes (0.87) improved better than students in control classes (0.68). It can be concluded that the SMART-KU module based on local wisdom in PBL effectively improves students' mathematical problem-solving ability. This research contributes to alternative learning to improve students' mathematical problem-solving ability, which combines local wisdom-based teaching materials and contextual and meaningful learning models.

Keywords:

Local Wisdom, Problem-Based Learning, Mathematical Problem Solving, SMART-KU Module

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INTRODUCTION

Mathematics is one of the core subjects in elementary school. Mathematics not only emphasizes mastery of concepts and calculation operations, but also encourages students to be able to solve various problems in real life systematically. Daily life always involves mathematical operations (Rizki et al., 2023). Mathematics learning aims to develop mathematical reasoning, mathematical representation, mathematical connection,



mathematical communication, and mathematical problem-solving ability (NCTM, 2000). Based on this, mathematical problem-solving is one of the standard and important abilities for students to master (Amaliyah et al., 2023; Amaliyah & Santoso, 2022).

Students need to have good mathematical problem-solving ability in learning mathematics (Riswari et al., 2023). Mathematical problem solving is a process that uses the power and benefits of mathematics to solve problems, a method of finding solutions through the steps of solving a problem (Haryanti & Sari, 2019). Polya suggested 4 steps of mathematical problem solving ability, namely: (1) understand the problem, (2) make a plan, (3) implement the plan, and (4) check the results (Liljedahl et al., 2016).

However, the results of the PISA (Program for International Student Assessment) study show that the mathematical literacy ability of Indonesian students is below the average of OECD countries, as well as showing a downward trend, with scores of 386, 379, and 366 (OECD, 2016, 2019, 2023). In addition, Indonesia's National Education Report Card data shows numeracy ability at the primary school level based on AN (National Assessment), where in AN 2022, 46.67% of students met above minimum competency, in AN 2023, 62.62%, and in AN 2024 69.58% (BSKAP, 2023, 2024, 2025). These results indicate that most Indonesian students still struggle to solve math problems in real-life contexts (Nugroho et al., 2025).

One school that shows a similar trend is SD Negeri 1 Mijen, Kudus District. Based on the results of teacher evaluations and documents of students' summative assessment results, it was found that more than 60% of grade V students had difficulty in solving math problems that required understanding concepts and applying problem-solving strategies. This condition is exacerbated by the learning approach that is still conventional, teacher-centered, and has minimal use of interactive and contextual media. The learning resources used also tend not to accommodate local wisdom that can bring math concepts closer to the reality of students' lives. As a result, mathematics learning becomes less meaningful and fails to generate students' active involvement in solving problems independently.

One of the relevant learning models to overcome these problems is Problem-Based Learning (PBL). The PBL model utilizes real problems as a starting point for learning, so that student learning activities are more systematic and contextual in problem-solving (Yarmi et al., 2024). The syntax of PBL is: (1) problem orientation, (2) organizing students to learn, (3) guiding individuals and groups, (4) developing and presenting work, and (5) analyzing and evaluating the problem-solving process (Sari et al., 2025). However, the effectiveness of PBL is greatly influenced by the quality of learning resources used.

Electronic learning modules (e-modules) integrated with local wisdom are relevant for PBL that emphasizes contextual problems. E-modules can be used as teaching materials because they have the advantage of being accessible anywhere and integrated with video, audio, and images that help students understand the lesson (Putri et al., 2024). In line with the demands of learning in the digital age, the use of interactive E-Modules can be a solution to provide independent, flexible, and engaging learning media (Güler et al., 2022; Wijaya et al., 2022). Interactive media technology can create collaborative and communicative mathematics learning, support conceptual understanding and problem solving, and have a positive impact on students' mathematics achievement (Juandi et al., 2021; Ran et al., 2022). Meanwhile, the integration of e-modules with local wisdom can bridge a more contextual and meaningful understanding. E-modules integrated with local wisdom not only increase the desire to learn, but also strengthen local culture (Kertiyani et al., 2024; Sinukaban et al., 2024).

The SMART-KU module (Smart Mathematics Module of Real-life Tradition - Kudus) in this study was designed as an e-module integrated with Kudus local wisdom. The SMART-KU e-module is equipped with Kudus local culture-based learning videos and integrated with a digital platform for interactive assessment. This module also presents

mathematical problem-solving questions that are contextualized with local traditions of Kudus, such as Dandangan, Gusjigang, and the values of Wali Songo. Kudus is one of the regions rich in culture and local wisdom, so this potential is worthy of being used as the basis for developing teaching materials.

The use of SMART-KU e-modules in Problem-Based Learning (PBL) in this study combines local cultural values and learning materials, so it is expected to create contextual and meaningful learning for elementary school students and be able to improve their mathematical problem-solving ability. In line with several studies that show that modules based on local cultural wisdom can improve students' cultural knowledge, critical thinking, and mathematical problem-solving ability (Annam et al., 2024; Paramita et al., 2024; Wahyudi et al., 2025). In addition, the Problem-Based Learning Model combined with local wisdom has also proven effective in improving the mathematical problem-solving and character of elementary school students (Ula et al., 2024; Wiradnyana et al., 2024).

Based on this background, this study aims to examine the effectiveness of using SMART-KU e-modules in Problem-Based Learning (PBL) on the mathematical problem-solving ability of elementary school students. This research uses a comparative quantitative study, which compares the learning outcomes of students who use the SMART-KU e-module in PBL with those of students who follow conventional learning. This research will significantly provide a comprehensive understanding of the appropriate learning for developing problem-solving ability.

METHODS

This research is a quantitative study with a quasi-experimental design. The specific type of design uses a non-equivalent control group. The reason for choosing this design is that it involves an experimental class and a control class, so it is suitable for comparative studies (Sugiyono, 2023). Schematically, this design is depicted in Table 1.

Table 1. Non-equivalent control group design

Class	Pretest	Treatment	Posttest
Experimental Class	O ₁	X	O ₂
Control Class	O ₃	Y	O ₄

Explanation:

O₁ : Pretest for experimental class.

O₂ : Posttest for experimental class.

O₃ : Pretest for control class.

O₄ : Posttest for control class.

X : Treatment for experimental class (SMART-KU module in Problem-Based Learning model).

Y : Treatment for the control class (conventional model in the form of a lecture method).

Based on Table 1, the research procedure was divided into three stages. First, it began with administering a pretest to students to measure their initial problem-solving abilities. Second, different treatments were given to the experimental and control classes. The experimental class was given treatment in the form of applying the SMART-KU module in the Problem-Based Learning model, while the control class was given conventional treatment in the form of lectures. The third or final stage involved administering a posttest to students to measure their final problem-solving abilities.

This research was conducted at SDN 1 Mijen, Kaliwungu, Kudus. The population was all fifth-grade students. The study involved 32 students selected through cluster sampling, with 16 students in the experimental group and 12 in the control group. The experimental class was treated in the form of learning with the SMART-KU module in the Problem-Based Learning (PBL) model, while the control class learned using the conventional model in the form of a lecture method.

Data collection techniques through tests. The tests given were a pretest and a posttest of mathematical problem-solving ability. The mathematical problem-solving ability test was given to both experimental and control classes. Indicators of mathematical problem-solving ability refer to Polya's theory, which includes: (1) understanding the problem, (2) making a plan, (3) implementing the plan, and (4) checking the results (Liljedahl et al., 2016).

Data analysis techniques used descriptive and inferential statistics. Descriptive statistics were used to describe the data from the experimental and control classes. Inferential statistics used are parametric statistics, namely paired sample t-test to see the average difference in pretest and posttest results in each experimental and control class, and independent sample t-test to see the average difference in posttest results between experimental and control classes. In addition, the N-Gain score was also measured to see the improvement of problem-solving ability in each experimental class and control class. The results of the N-Gain score were interpreted based on the categories proposed by Hake (1999) as shown in Table 2.

Table 2. N-Gain score interpretation

N-Gain Score	Interpretation
Score ≥ 0.7	High
$0.3 < \text{Score} < 0.7$	Medium
Score ≤ 0.3	Low

RESULTS & DISCUSSION

The mathematical problem-solving ability test, consisting of a pretest and posttest, was given to both experimental and control classes. First, the pretest was given before the class received treatment. Second, the posttest was given after the class received treatment. The experimental class received treatment in the form of applying the SMART-KU module in the Problem-Based Learning (PBL) model, while the control class received treatment in the form of learning with a conventional model through the lecture method. Data from both classes were tested with descriptive statistics to determine the minimum, maximum, and average values, as shown in Table 3.

Table 3. Descriptive statistics results

Problem-Solving	N	Minimum	Maximum	Mean
Pretest_ Experiment	16	14	40	28.00
Posttest_ Experiment	16	76	100	90.25
Pretest_ Control	16	10	36	22.25
Posttest_ Control	16	44	94	74.13

Table 3 shows the achievement of mathematical problem-solving ability in the experimental and control classes. It can be seen that the experimental class got a better achievement. The experimental class pretest results showed a minimum value of 14, a maximum value of 40, and an average of 28, while the posttest results showed a minimum

value of 76, a maximum value of 100, and an average of 90.25. Based on this, the experimental class achieved an average increase of 62.25 from pretest to posttest.

The control class showed a lower achievement. The control class pretest results showed a minimum score of 10, a maximum score of 36, and an average score of 22.25, while the posttest results showed a minimum score of 44, a maximum score of 94, and an average score of 74.13. Based on this, the experimental class achieved an average increase of 51.88 from pretest to posttest.

The mathematical problem-solving ability data from the experimental and control classes were then tested for prerequisites. This test needs to be done to see if the data is feasible to be tested with parametric statistics. The prerequisite tests include the normality test and homogeneity test, whose results are shown in Table 4 and Table 5.

Table 4 shows the results of the prerequisite test of normality of mathematical problem-solving ability data from experimental and control classes. In Table 4, the normality test referred to is the Shapiro-Wilk because of the small amount of data (<50), namely 16, with the basis for decision making, namely if Sig. > 0.05, then the data is normally distributed. It can be seen that the Shapiro-Wilk test results show the experimental class pretest data Sig. = 0.739 (> 0.05), experimental class posttest Sig. = 0.174 (> 0.05), control class pretest Sig. = 0.635 (> 0.05), and control class posttest Sig. = 0.437 (> 0.05). Based on these results, the pretest and posttest data from both the experimental and control classes are normally distributed.

Table 4. Normality test results

Problem-Solving	Shapiro-Wilk		
	Statistic	Df	Sig.
Pretest_Experiment	.964	16	.739
Posttest_Experiment	.921	16	.174
Pretest_Control	.959	16	.635
Posttest_Control	.947	16	.437

Table 5. Homogeneity test results

Problem-Solving	Levene Statistic	Df1	Df2	Sig.
Pretest Experiment_Control	.000	1	30	.984
Posttest Experiment_Control	3.376	1	30	.076

Table 5 shows the results of the homogeneity test of mathematical problem-solving ability data from experimental and control classes. The homogeneity test applies the Levene test, with the basic basis for decision making, namely, if Sig. > 0.05, then the data is homogeneous. It can be seen that the pretest data of the experimental class and control class show Sig. = 0.984 (> 0.05), while the posttest data shows Sig. = 0.076 (> 0.05). Thus, it can be concluded that the data fulfill the homogeneity requirement.

After the data meet the normality and homogeneity requirements, the data can be tested with parametric statistics. First, the data was tested with a paired sample t-test to see the difference in pretest and posttest averages in each experimental class and control class. Second, the data were tested with an independent sample t-test to see the difference in posttest means between the experimental and control classes. The results of the paired sample t-test and independent sample t-test are shown in Table 6 and Table 7

Table 6. Paired sample t-test results

Problem-Solving	Mean	t	Df	Sig. (2-tailed)
Pair 1 (Pre-Ex—Post-Ex)	-62.250	-49.277	15	.000
Pair 2 (Pre-Con—Post-Con)	-51.875	-23.973	15	.000

Table 7. Independent sample t-test results

Problem-Solving	Mean Difference	t	Df	Sig. (2-tailed)
Posttest Equal variances assumed	16.125	4.162	30	.000
Ex_Con Equal variances not assumed	16.125	4.162	24.617	.000

Table 6 is the result of the paired sample t-test, which shows the average difference in pretest and posttest results from each experimental class and control class. The basis for decision-making is if Sig. (2-tailed) ≤ 0.05 , then there is a significant average difference in students' mathematical problem-solving ability between before and after treatment. It can be seen that in the experimental class (see Pair 1) Sig. (2-tailed) = 0.000 (≤ 0.05), while the control class (see Pair 2) also shows Sig. (2-tailed) = 0.000 (≤ 0.05). Based on this, there is a significant average difference in students' mathematical problem-solving ability between before and after treatment in both experimental and control classes.

Table 7 is the result of an independent sample t-test, which shows the average difference in posttest between the experimental and control classes. The basis for decision-making is if Sig. (2-tailed) ≤ 0.05 , then there is a significant average difference in students' mathematical problem-solving ability between the experimental and control classes. It can be seen that the results of the independent sample t-test show Sig. (2-tailed) = 0.000 (≤ 0.05). Thus, it can be concluded that there is a significant average difference in students' mathematical problem-solving ability between the experimental and control classes.

To see the difference in the improvement of mathematical problem-solving ability, the N-Gain score test was conducted. This test was conducted to compare the category of improvement in students' mathematical problem-solving ability between the experimental and control classes. The results of the N-Gain score test are shown in Table 8.

Table 8. N-Gain score test results

Class	Minimum	Maximum	Mean	Interpretation of Mean
Experimental Class	0.72	1	0.87	High
Control Class	0.35	0.91	0.68	Medium

Table 8 is the result of the N-Gain score test, which shows the category of improvement in each experimental class and control class. It can be seen that the average N-Gain score in the experimental class is 0.87 in the high improvement category, while in the control class, it is 0.68 in the medium improvement category. Thus, the experimental class that received learning with the SMART-KU module in Problem-Based Learning experienced an increase in mathematical problem-solving ability better than the control class that only received conventional learning models through lectures.

Based on the results in this study, there are contrasting differences between the experimental class that learned with the SMART-KU module in Problem-Based Learning (PBL) and the control class that only learned with the conventional model through lectures. First, the paired sample t-test results showed a real average difference in students' mathematical problem-solving ability before and after treatment in each experimental class and control class, with the experimental class having Sig. (2-tailed) = 0.000 (≤ 0.05) and the control class also has Sig. (2-tailed) = 0.000 (≤ 0.05). Second, the results of the independent sample t-test showed a real average difference in students' mathematical problem-solving ability between the experimental and control classes, with Sig. (2-tailed) = 0.000 (≤ 0.05). Third, the N-Gain score test results showed differences in the category of improvement that occurred between the experimental and control classes, namely, the average N-Gain score in the experimental class of 0.87 in the high improvement category, while in the control class of 0.68 in the medium improvement category. This confirms that

learning with the SMART-KU module in PBL has a more significant impact on improving students' mathematical problem-solving ability than conventional learning through lectures. This contrasting difference is reinforced by the comparison of the acquisition of the N-Gain score of each indicator in the experimental class and control class, as shown in Figure 1.

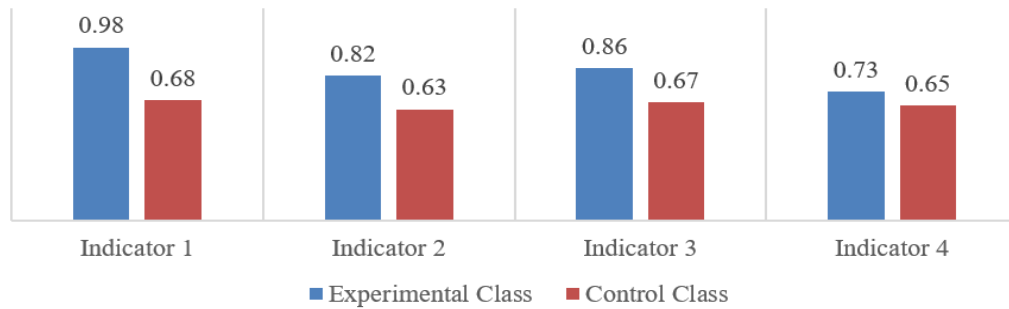


Figure 1. Mean of N-Gain score for each indicator

In indicator 1 (understanding the problem), the difference in achievement between the experimental class and the control class is the highest compared to the difference in achievement in other indicators. The experimental class got an N-Gain score of 0.98 with a high category, while the control class was 0.68 with a medium category. This shows that students in the experimental class were better able to understand the contextual problems presented. Understanding the problem is an essential part of mathematical problem-solving ability (Putri et al., 2022). The SMART-KU module in Problem-Based Learning (PBL) facilitates contextualized learning with local wisdom of Kudus, so that students in the experimental class become more adept at identifying the information given and what is asked from the problem. This creates meaningful learning because it is close to students' daily lives, so they are able to understand the problems better. In line with the claim Pramitasuri et al. (2025) that a contextualized approach makes it easier for students to understand the problem, thus affecting their problem-solving ability for the better.

In indicator 2 (making plans), the experimental class got an N-Gain score of 0.82 with a high category, while the control class was 0.63 with a medium category. This means that students in the experimental class can develop a problem-solving plan more carefully than students in the control class. Learning with the SMART-KU module in PBL involves activities that guide students to be skillful in determining the right equation or formula to solve problems. In line with Permadani et al. (2025) which found that the integration of PBL and appropriate media can involve students in designing problem-solving steps more collaboratively.

In indicator 3 (implementing the plan), the experimental class got an N-Gain score of 0.86 with a high category, while the control class was 0.67 with a medium category. This indicates that students in the experimental class were more careful in implementing the problem-solving plan. Learning with the SMART-KU module in PBL can guide students to have accuracy in mathematical calculations during problem-solving activities. In line with the claim Ramadhan et al. (2025) that the right media can facilitate students to reason appropriately in implementing problem-solving plans.

In indicator 4 (checking results), the experimental class got an N-Gain score of 0.73 with a high category, while the control class was 0.65 with a medium category. This means that students in the experimental class are more skilled in evaluating the results of the problem-solving they do. The SMART-KU module in PBL encourages students to rematch the results they get with the context of the problem, so they are better able to provide the right mathematical problem-solving answers. In line with what was stated by Riyadi et al.

(2021) that checking results involves understanding the relationship between the context of the problem and the calculation results that have been obtained.



Figure 2. Design of SMART-KU module based on local wisdom

The SMART-KU module design used in Problem-Based Learning (PBL) in this study was able to facilitate students in the experimental class to improve their mathematical

problem-solving ability. For example, the module design (see Figures 2 (b) and 2 (c)) presents contextual problems based on the local wisdom of Kudus, making it relevant to support learning through PBL. The module also contains components that encourage the activity of understanding the stages of solving mathematical problems (see Figures 2 (d), 2 (e), 2 (f)). In addition, the module provides instructions for group discussion activities to practice problem solving during learning in PBL (see Figure 2 (g)). The module also contains interactive assessments of mathematical problem solving (see Figure 2 (h)) and learning videos (see Figure 2 (i)) that can foster students' enthusiasm during the learning process.

Through PBL, students are encouraged to identify and solve problems independently, while the teacher acts as a facilitator who guides and supports the learning process (Kurniawati et al., 2024). During learning in this study, PBL encouraged students to think critically, analytically, and logically about problems and their solutions. The class becomes more dialogic, where students actively exchange opinions with friends in one group and with other groups. PBL involves students actively in analytical ability, discussion, investigation, and presentation (Sulistiyawati et al., 2023; Sumaji et al., 2025). In addition, PBL is effective in improving critical thinking, mathematical problem solving, and motivation (Ahdhianto et al., 2020; Alashwal & Barham, 2025; Febrianto & Aeni, 2024).

SMART-KU module design in the form of e-modules and based on local wisdom provides meaningful learning experiences for students to improve their mathematical problem-solving ability. The e-module design is able to facilitate access and enrich students' learning experience, while the integration with local wisdom supports a more contextual understanding in solving mathematical problems. E-modules can be effective and practical teaching materials for both teachers and students to improve the quality of learning (Ariani et al., 2022; Hakim et al., 2024). Through the SMART-KU e-module, during learning in this study, students get contextual and meaningful learning experiences through activities and learning videos. Students are also actively involved to practice mathematical problem solving inspired by local wisdom. Students' intense interaction with these problems strengthens their mathematical problem-solving ability. Students can work on mathematical problem solving more structured, logical, and precise in their solution strategies and results. In line with the claim that e-modules allow students to expand problem-solving activities and flexibility of access to content (Rahmatullah et al., 2025; Utami et al., 2024). The integration of local wisdom in the module can attract students' enthusiasm and bridge the gap between cultural knowledge and understanding of mathematical concepts, to improve students' critical thinking and mathematical problem-solving ability (Annam et al., 2024; Paramita et al., 2024; Ula et al., 2024).

Overall, this study has proven that the SMART-KU module based on local wisdom in Problem-Based Learning (PBL) is effective in improving students' mathematical problem-solving ability. The SMART-KU module in PBL is able to create learning that attracts students' enthusiasm so that they are actively involved in identifying and solving mathematical problems, thinking critically, analytically, and logically, and getting meaningful learning experiences that are contextualized with local wisdom around them. Thus, this research can contribute as a learning resource for teachers for learning alternatives that are integrated with local wisdom and facilitate the development of students' mathematical problem-solving ability.

CONCLUSION

Based on the results and discussion that have been presented, it can be concluded that the SMART-KU module based on local wisdom in Problem-Based Learning (PBL) is effective in improving students' mathematical problem-solving ability. The mathematical problem-solving ability of students in the experimental class who studied with the SMART-KU module and PBL improved better than that of students in the control class who studied conventionally through lectures. This reinforces that students' mathematical problem-solving ability needs to be facilitated with the right teaching materials and learning models.

However, there are some limitations in this study. First, this study focused on the elementary school level, specifically grade V. Further research is needed at the junior or senior high school level. Further research is needed at a higher level for comparison to this research. Secondly, this study compared e-module and PBL teaching materials with conventional learning models through lectures. Further research is needed to compare e-modules and PBL teaching materials with other teaching materials and learning models.

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