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## ARTICLE INFORMATION

# Problem-based learning with scaffolding and equation board media for facilitating junior high school students' mathematical modelling ability

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# PROBLEM-BASED LEARNING WITH SCAFFOLDING AND EQUATION BOARD MEDIA FOR FACILITATING JUNIOR HIGH SCHOOL STUDENTS' MATHEMATICAL MODELLING ABILITY

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**ABSTRACT**

This study was motivated by classroom observations and interviews with mathematics teachers at SMP Nahdlatul Ulama (NU) Simo (a private Junior High School), which revealed that students experienced difficulties in mathematical modelling, particularly in the topic of Two-Variable Linear Equation Systems (SPLDV). These challenges were associated with teacher-centered instruction and the limited use of learning media that engaged students. To address these issues, Problem-Based Learning (PBL) integrated with the scaffolding method and supported by equation board media was implemented. This study aimed to describe students' mathematical modelling achievement, learning responses, and classroom participation after the implementation of the instructional approach. A descriptive quantitative method with a one-shot case study design, classified as a one-group posttest-only pre-experimental design, was employed and supported by classroom observations. The participants were 26 students of 8th grade at SMP NU Simo. Data were collected through mathematical modelling tests, student response questionnaires, and classroom observations. The data were analyzed descriptively using test scores, questionnaire percentages, and observation results to determine students' achievement categories. The findings showed that students' mathematical modelling ability was categorized as good, with an average score of 80. Student responses toward the learning process were classified as very good, with an average percentage of 89%, while classroom participation reached the good category, with an average percentage of 79%. These findings indicate that implementing PBL integrated with scaffolding and equation board media was associated with students' mathematical modelling achievement, positive learning responses, and active classroom participation.

Keywords: Problem-Based Learning, Scaffolding, Equation Board, Mathematical Modelling, Linear Equation of Two Variable Systems.

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## INTRODUCTION

Mathematics plays a fundamental role in education as it fosters students' logical, critical, analytical, and systematic thinking skills. In twenty-first-century education, mathematics instruction extends beyond conceptual understanding and increasingly emphasizes students' ability to apply mathematical knowledge to solve real-world problems. One of the essential competencies required in this process is mathematical modelling ability. This ability involves transforming real-world situations into mathematical models, solving the models, and interpreting the solutions based on the original context of the problems (Blum & Borromeo Ferri, 2009).

Furthermore, learning activities that emphasize mathematical modelling encourage students to connect contextual situations with mathematical representations in a structured and systematic manner (Cevikbas et al., 2022). Recent studies have also demonstrated that mathematical modelling activities are effective in developing students' reasoning, mathematical connections, and higher-order thinking skills because students are required to analyse real situations and formulate mathematical representations independently (Dewi & Nurjanah, 2022; Siller et al., 2023). Furthermore, mathematical modelling also promotes sustainable and meaningful learning because it enables students to apply mathematical knowledge to real-life situations and continue developing their quantitative reasoning skills beyond formal instruction (Lindl et al., 2025). This is consistent with the view that mathematical modelling supports long-term conceptual understanding through contextual problem exploration in mathematics learning. This is consistent with the view that mathematical modelling supports long-term conceptual understanding through contextual problem exploration in mathematics learning. This perspective is also consistent with the current direction of mathematics education, which emphasizes meaningful learning experiences through contextual activities that actively involve students in constructing mathematical understanding (Asmana et al., 2023).

Beyond facilitating the solution of real-world problems, mathematical modelling is increasingly regarded as a key competency for fostering twenty-first-century skills, including creativity, communication, collaboration, and critical thinking. Mathematics instruction is therefore expected to help students apply knowledge flexibly rather than merely remember mathematical procedures. Through modelling activities, students are not only required to apply formulas and procedures. Still, they are also encouraged to analyse situations, identify important information, formulate assumptions, and justify the solutions they obtain. The modelling process engages students in higher-order thinking processes involving reasoning, interpretation, evaluation, and reflection. According to (OECD, 2023), mathematical literacy requires students to formulate, employ, and interpret mathematics in various contexts. Consequently, mathematical modelling is considered an essential competency that can support the development of problem-solving abilities and prepare students to face increasingly complex challenges in modern society (Cevikbas et al., 2022; Siller et al., 2023).

Despite its recognized importance in mathematics education, empirical evidence suggests that students' mathematical modelling abilities remain insufficiently developed. This situation is reflected in international assessment results indicating that Indonesian students still demonstrate limited mathematical literacy, particularly in solving problems related to real-world situations (OECD, 2023). One factor contributing to this issue is the learning process, which remains largely teacher-centered and provides students with limited opportunities to construct their own understanding during classroom activities actively (Fajriani et al., 2021). Previous studies also indicate that active learning strategies emphasizing contextual learning can improve students' conceptual understanding (Rohmah et al., 2024). Consequently, many students become accustomed to routine exercises with predetermined procedures and have insufficient experience in solving open-ended and contextual problems. Students frequently experience difficulties in determining variables independently, constructing mathematical relationships, and explaining the meaning of their solutions. Similar findings were reported by (Mita & Ihsanudin, 2024), who explained that students often encounter obstacles in understanding contextual information and transforming it into mathematical representations, resulting in low mathematical problem-solving performance. These findings suggest the need for instructional approaches that actively engage students in constructing and applying mathematical models in meaningful contexts.

These difficulties become particularly evident in learning the Two-Variable Linear Equation System (SPLDV), a topic that requires students to translate contextual situations into mathematical representations. In learning SPLDV, students frequently encounter challenges in transforming word problems into appropriate mathematical models. Some students still experience difficulties in determining variables, constructing equations, and interpreting solution results. These difficulties are associated with students' limited ability to represent and understand abstract concepts. Previous research has explained that learning environments that do not actively involve students can negatively affect their mathematical problem-solving abilities (Mita & Ihsanudin, 2024).

Another issue frequently observed in mathematics classrooms is the limited opportunity for students to communicate and justify their mathematical ideas. Predominantly teacher-centered learning activities may reduce students' participation in discussions and investigations, causing them to become passive recipients of information. Such instructional practices can hinder the development of reasoning and modelling competencies because mathematical modelling requires students to communicate assumptions, discuss alternative strategies, and evaluate the reasonableness of solutions. Therefore, mathematics learning should provide opportunities for students to collaborate, exchange ideas, and actively participate in constructing mathematical knowledge (Lusiana et al., 2021).

One instructional approach that can be employed to address these problems is Problem Based Learning (PBL). This model uses contextual problems as the starting point of the learning process and encourages students to participate actively in finding solutions to the problems. The implementation of Problem Based Learning has the potential to enhance students' higher-order thinking and problem-solving abilities. Several previous studies have reported that Problem Based Learning is effective in enhancing students' critical thinking, mathematical problem-solving abilities, and independent learning processes (Chrisdiyanto & Hamdi, 2023; Mitrayana & Juandi, 2023). Furthermore, recent findings indicate that the PBL model can promote greater student participation and strengthen critical thinking skills in mathematics learning (Lusiana et al., 2021). Similarly, (Dewi & Nurjanah, 2022) reported that Problem Based Learning facilitates the development of mathematical connections because students are required to relate mathematical concepts to contextual situations. A meta-analysis conducted by (Fitriyah et al., 2022) revealed that Problem Based Learning has a significant positive effect on students' mathematical reasoning abilities. Recent studies also indicate that Problem Based Learning supported by appropriate learning resources and media can improve students' mathematical problem-solving abilities and learning achievement by providing opportunities for active investigation and collaborative learning (Tiyasari & Suparman, 2023; Wahyuni et al., 2024). In addition, PBL has been widely implemented in mathematics classrooms because it encourages students to engage in real problem situations, work collaboratively, and construct their own knowledge through inquiry-based activities.

Nevertheless, the implementation of Problem Based Learning may not achieve optimal outcomes when students do not receive guidance that corresponds to their level of understanding. Consequently, additional instructional support is required to assist students in developing conceptual understanding progressively. One approach that can provide such support is scaffolding. Scaffolding refers to the provision of adaptive and gradually reduced support that enables students to accomplish learning tasks independently. In mathematical modelling instruction, scaffolding should be provided gradually and adjusted to students' learning needs so that they can progressively develop modelling competencies and solve problems independently (Siller et al., 2023). The concept of scaffolding is based on the theory of the Zone of Proximal Development (ZPD) proposed by Vygotsky (1978). Several studies have shown that scaffolding can help students understand mathematical concepts more effectively and improve their mathematical thinking skills (Fajriani et al., 2021; Prasetyo et al., 2020). (Ernawati et al., 2022) reported that the integration of scaffolding strategies within Problem Based Learning environments can improve students' mathematical problem-solving abilities and promote independent learning processes. However, previous studies have primarily focused on students' mathematical problem-solving abilities and conceptual understanding. Limited attention has been given to how scaffolding integrated with Problem-Based Learning facilitates students' mathematical-modelling abilities, particularly in the context of the Two-Variable Linear Equation System (SPLDV). Therefore, further investigation is needed to examine the role of this instructional integration in supporting students' mathematical-modelling achievement. Through adaptive assistance and guiding questions, students are encouraged to solve mathematical problems independently and develop deeper conceptual understanding. Furthermore, recent studies have shown that adaptive scaffolding strategies help students organize information systematically, construct mathematical relationships, and develop independent reasoning abilities during mathematical investigations (Alaiya et al., 2024). Furthermore, recent studies have shown that adaptive scaffolding strategies facilitate students in organizing information systematically. Similarly, the integration of scaffolding techniques within Problem Based Learning environments has been reported to improve students' mathematical problem-solving abilities and support independent learning processes through gradual and adaptive assistance (Mohamad Salam et al., 2024). This finding is also supported by other studies, which show that scaffolding within PBL helps students overcome difficulties in understanding concepts by providing step-by-step guidance until they can solve problems independently (Tazkia & Siswono, 2023; Trisnawati & Mahmudi, 2024).

Besides instructional models and methods, learning media also play an important role in determining the success of mathematics learning. Instructional media can facilitate students' understanding of abstract mathematical concepts by presenting them in more concrete and meaningful forms. The use of concrete media can also increase students' learning motivation and help them understand relationships among mathematical concepts (Arsyad, 2019). Other studies have shown that concrete learning media can enhance student engagement during mathematics instruction (Nurdyansyah & Fahyuni, 2020). Moreover, interactive and concrete learning media enable students to visualize abstract mathematical ideas and construct conceptual understanding more effectively.(Nugraha et al., 2023) reported that the integration of Problem Based Learning with interactive digital media significantly improved students' learning achievement and engagement during mathematics instruction. Accordingly, this study employed equation board media to assist students in visualizing SPLDV equations more clearly and systematically. Through direct manipulation of mathematical representations, students are expected to understand relationships among variables better, construct equations more accurately, and solve contextual problems in a more meaningful manner. Unlike conventional instructional media that primarily present mathematical concepts visually, the equation-board media enables students to manipulate variables and equations directly, thereby supporting the process of constructing mathematical models from contextual problems. In this study, scaffolding was embedded within each phase of Problem-Based Learning through guiding questions, adaptive assistance, and gradual support adjusted to students' needs. The integration of Problem-Based Learning, scaffolding, and equation-board media is particularly relevant to mathematical modelling because it provides opportunities for students to analyse contextual situations, formulate mathematical representations, and interpret solutions systematically.

Various studies on Problem Based Learning, scaffolding, and instructional media have been conducted. Nevertheless, studies integrating Problem Based Learning, scaffolding strategies, and instructional media to facilitate students' mathematical modelling abilities in

SPLDV learning remain scarce. Most previous studies have primarily focused on students' learning achievement and mathematical problem-solving abilities, whereas investigations specifically examining mathematical modelling abilities within the context of Problem Based Learning, scaffolding, and SPLDV instruction remain relatively limited and require further exploration. Previous research has also examined contextual mathematics learning through PMRI and active learning strategies; however, studies specifically integrating Problem Based Learning, scaffolding, and equation-board media to facilitate mathematical modelling remain limited (Rohim & Asmana, 2018; Rohmah et al., 2024). Moreover, previous studies have generally examined Problem Based Learning, scaffolding, and instructional media separately and have paid limited attention to integrating these components to facilitate mathematical modelling competencies, particularly in learning the Two-Variable Linear Equation System material (Siller et al., 2023). Accordingly, this study contributes to the existing body of knowledge by examining students' mathematical-modelling achievement, responses, and classroom participation following the integration of Problem Based Learning, scaffolding strategies, and equation board media in learning the Two-Variable Linear Equation System (SPLDV).

The novelty of this study lies not only in integrating Problem Based Learning, scaffolding strategies, and equation board media but also in examining their role in facilitating students' mathematical modelling achievement, responses, and classroom activities in the context of the Two-Variable Linear Equation System (SPLDV). While previous studies have mainly focused on learning achievement and problem-solving abilities, this study specifically investigates mathematical modelling as an essential competency in mathematics education.

Based on the foregoing discussion, this study aims to describe the level of students' mathematical modelling achievement, responses, and classroom participation following the implementation of Problem Based Learning integrated with scaffolding and equation board media in learning the Two-Variable Linear Equation System (SPLDV).

## METHOD

This research adopted a quantitative descriptive approach with a one-shot case study design, categorized as a pre-experimental one-group posttest-only design, and was complemented by observations conducted during classroom instruction. A descriptive research approach was employed to obtain a detailed account of students' mathematical-modelling achievement, responses, and classroom participation after the implementation of Problem-Based Learning integrated with scaffolding and supported by equation-board media. The one-shot case study design was chosen because the research focused on a single group of participants that received the instructional treatment without involving a control or comparison group. A one-shot case study design is appropriate for describing the outcomes of an instructional intervention because it involves a single group receiving treatment followed by posttest measurement without pretest administration or a comparison group. Qualitative descriptive research enables researchers to understand phenomena comprehensively by emphasizing contextual interpretation and in-depth descriptions of participants' experiences and behaviours (Nurochmah & Kharisudin, 2023). Within this approach, a one-shot case study design was adopted because the study involved only one group of participants who received a particular instructional treatment without the inclusion of a comparison or control group.

In this study, the participants underwent an instructional intervention involving the Problem-Based Learning model integrated with the scaffolding method and supported by equation-board media. After the intervention was completed, data were obtained through tests, questionnaires, and classroom observations to provide a description of the outcomes resulting from the implemented learning process.

**Table 1.** Research Design

| Design | Notation |
|---|---|
| One Shot Case Study | $\boldsymbol{X \rightarrow O}$ |

Description:
$X$ : Implementation of the *Problem Based Learning* model integrated with the *scaffolding* method and assisted by equation board media
$O$ : Tests, questionnaires, and observations conducted after the instructional treatment.

The study was conducted at private Junior High School (SMP) NU Simo on May 16–17, 2026. The participants consisted of 26 students from class VIII A. The participants were selected using a purposive sampling technique, which involves selecting research subjects based on specific criteria and considerations that are aligned with the objectives and characteristics of the study. Class VIII A was selected purposively based on the recommendation of the mathematics teacher because the students had previously studied prerequisite algebraic concepts and demonstrated varying levels of mathematical abilities, making the class suitable for investigating students' mathematical modelling abilities in the Two-Variable Linear Equation System (SPLDV) material. Therefore, class VIII A was considered an appropriate setting for investigating students' mathematical modelling abilities through the proposed instructional intervention.

This study focused on implementing the Problem-Based Learning model integrated with the scaffolding method and supported by equation board media to facilitate students' mathematical modelling abilities in the SPLDV material. The implementation of learning followed the stages of Problem Based Learning, namely problem orientation, organizing students for learning, guiding investigations, developing and presenting work, and evaluating the problem-solving process. Throughout these stages, scaffolding was provided gradually according to students' learning needs through guiding questions, prompts, explanations, and feedback to support students in constructing mathematical understanding independently.

Data collection was carried out through tests, questionnaires, and observations to obtain comprehensive information regarding students' mathematical modelling abilities, responses, and activities during the implementation of learning. The use of multiple data collection techniques enabled the researchers to obtain comprehensive and credible information through the corroboration of evidence across different instruments (Nurochmah & Kharisudin, 2023).

**Table 2.** Research Instrument

| Research Instrument | Objective | Data Obtained |
|---|---|---|
| Students' mathematical modelling ability test | Measuring students' mathematical modelling abilities | Students' mathematical modelling ability scores |
| Student response questionnaire | Identifying students' responses toward learning | Student response data |
| Student activity observation sheet | Observing student activities during learning | Student activity data |

To facilitate the data collection process, the study employed three research instruments, namely mathematical modelling ability test items, student response questionnaires, and observation sheets used to assess students' activities during classroom learning. The mathematical modelling ability test was developed based on several indicators of mathematical modelling, namely identifying information from contextual problems, determining variables and assumptions, constructing mathematical models, solving the mathematical models, and interpreting the obtained solutions according to the original contexts of the problems. Meanwhile, the student response questionnaire and observation sheet were designed to provide information regarding students' perceptions and participation during the learning activities.

Before being administered, all research instruments underwent a validation process to determine their appropriateness and suitability for the objectives of the study. Instrument validation was conducted by two mathematics teachers from SMP NU Simo and one lecturer in Mathematics Education. Suggestions and recommendations provided by the validators were subsequently used as the basis for revising and improving the research instruments before implementation.

To ensure the credibility of the findings, data were collected using multiple instruments, including mathematical-modelling tests, student-response questionnaires, and classroom observations. Each instrument was used to obtain complementary information regarding students' mathematical-modelling achievement, responses, and classroom participation following the instructional implementation.

Data obtained from the mathematical modelling ability test were analysed by calculating students' scores and subsequently classifying them into predetermined achievement categories. Questionnaire and observation data were analysed using percentage calculations and descriptive interpretation to determine the categories of students' responses and learning activities during the implementation of learning. Therefore, descriptive statistics were used to summarize and interpret students' mathematical-modelling achievement, responses, and classroom activities following the instructional implementation.

**Table 3.** Data Collection and Analysis Techniques

| Data Source | Data Collection | Analysis Techniques |
|---|---|---|
| Students' mathematical modelling abilities | Description Test | Score and category analysis |
| Student responses | Questionnaire | Percentage and category analysis |
| Student activities | Observation | Percentage and category analysis |

The results of the data analysis were subsequently classified according to the predetermined assessment criteria presented in Tables 4 and 5

**Table 4.** Test Assessment Category

| Score | Category |
|---|---|
| $81 - 100$ | Very Good |
| $61 - 80$ | Good |
| $41 - 60$ | Enough |
| $21 - 40$ | Not Enough |
| $0 - 20$ | Very Less |

**Table 5.** Questionnaire and Observation Assessment Categories

| Percentage | Category |
|---|---|
| $81 - 100\%$ | Very Good |
| $61 - 80\%$ | Good |
| $41 - 60\%$ | Enough |
| $\leq 40\%$ | Not Enough |

## RESULT

The study took place at private Junior High School (SMP) NU Simo and included 26 students from class VIII A as the research participants. In the learning process, the researcher applied the Problem-Based Learning (PBL) model in combination with the scaffolding method and equation-board media to teach the Two-Variable Linear Equation System (SPLDV). The instructional activities were organized into several stages, beginning with problem orientation, followed by group discussion and investigation of contextual problems, presentation of the groups' work, and concluding with an evaluation of the learning process. The implementation of the learning activities during the study is presented in Figure 1.

**Figure 1.** Learning Process Using Problem Based Learning Model with Scaffolding Method

Throughout the learning activities, students were actively engaged in identifying relevant information, developing mathematical models, and determining solutions to contextual problems involving the SPLDV topic. To assess the implementation of the instructional process, data were obtained from mathematical-modelling ability tests, student response questionnaires, and observations of student activities throughout the classroom sessions. The resulting data were then analysed using descriptive methods to present an overview of students' mathematical-modelling abilities, their responses to the learning process, and their level of participation during the implementation of the instruction.

After the instructional activities had been completed, all 26 students were given a mathematical-modelling ability test covering the SPLDV material. The assessment had a maximum possible score of 60. The students achieved a mean raw score of 48, corresponding to an average score of 80 on the assessment scale. According to the established assessment criteria, the students' mathematical-modelling ability was classified as good.

**Table 6.** Mathematical Modelling Ability Test Results

| Description | Results |
|---|---|
| Number of students | 26 |
| Maximum score | 60 |
| Average student score | 48 |
| Average value | 80 |
| **Category** | **Good** |

In addition to evaluating the students' overall test performance, the study further examined their mathematical-modelling abilities by considering each individual modelling indicator. The analysis revealed that the understanding of contextual problems indicator achieved the highest percentage, reaching 82%, and was categorized as very good. Most students correctly identified known information, determined what was being asked in the problems, and recognized important elements presented in contextual situations.

The indicator of simplifying problems and making assumptions recorded a percentage of 76%, which was categorized as good. Several students demonstrated the ability to condense relevant contextual information and establish appropriate assumptions to facilitate the mathematical-modelling process. Similarly, the indicator of formulating mathematical models achieved a percentage of 78%, indicating that most students were capable of representing contextual situations in the form of mathematical equations involving two variables.

Furthermore, the indicator of solving mathematical models recorded a percentage of 80% and was categorized as good. Most students were able to determine appropriate solution strategies and solve the systems of linear equations correctly. However, the indicator of interpreting and re-checking the obtained results demonstrated the lowest percentage, namely 74%. Difficulties were still observed in interpreting the meaning of solutions according to the original contexts of the problems and in rechecking the correctness of answers.

Overall, the average percentage of students' mathematical modelling abilities reached 78%, indicating that students' mathematical modelling abilities were generally categorized as good.

**Table 7.** Results of Mathematical Modelling Capabilities Based on Indicators

| Indicators | Percentage | Category |
|---|---|---|
| Understand contextual problems | 82% | Very Good |
| Simplifying problems and making assumptions | 76% | Good |
| Formulate mathematical models | 78% | Good |
| Complete the mathematical model | 80% | Good |
| Interpret and re-check the results | 74% | Good |
| **Average** | **78%** | **Good** |

Beyond assessing students' mathematical-modelling abilities, this study also explored their responses and participation throughout the learning process. During the instructional activities, students engaged in collaborative work and utilized the equation-board media as they discussed and worked through contextual problems. An example of students' activities using the equation board media is presented in Figure 2.

**Figure 2.** Student Activities Using Equation Board Media

The findings of the student response questionnaire indicated that students showed positive responses toward the learning activities. Most students stated that the learning process helped them understand the SPLDV material more easily, increased their enthusiasm for learning, and encouraged their participation in classroom discussions and problem-solving activities.

The questionnaire results showed that the indicator of students' feelings of pleasure during learning achieved the highest percentage, reaching 91%, which was categorized as very good. Meanwhile, the indicators of students' enthusiasm for learning, ease of understanding the material, and new learning experiences recorded percentages of 90%, 88%, and 87%, respectively. Overall, the average percentage of students' responses reached 89%, indicating that students demonstrated highly positive perceptions toward the implemented learning process.

**Table 8.** Student Response Survey Results

| Indicator | Percentage | Category |
|---|---|---|
| Ease of understanding the material | 88% | Very Good |
| Students' enthusiasm for learning | 90% | Very Good |
| New learning experience | 87% | Very Good |
| Feeling of pleasure during learning | 91% | Very Good |
| **Average** | **89%** | **Very Good** |

In addition to investigating students' perceptions of the learning experience, the study also monitored their participation throughout the instructional process. As part of the learning activities, students were provided with opportunities to present the outcomes of their group discussions and communicate their problem-solving approaches to their classmates. An example of students presenting their discussion results is shown in Figure 3.

**Figure 3.** Presentation of Group Discussion Results

The observational data showed that students' participation throughout the learning process fell within the good category. Throughout the learning process, students participated in discussions, worked collaboratively with group members, and became involved in solving contextual problems provided during classroom activities.

Among the observed indicators, group cooperation achieved the highest percentage, reaching 84%, which was categorized as very good. The indicator of involvement in problem solving recorded a percentage of 81%, while active participation in learning reached 80%. Meanwhile, the indicators of presentation of discussion results and the ability to ask and answer questions achieved percentages of 78% and 76%, respectively. Overall, the average percentage of students' activities reached 79%, indicating that students demonstrated good participation throughout the learning process.

**Table 9.** Results of Student Activity Observation

| Indicator | Percentage | Category |
|---|---|---|
| Active participation in learning | 80% | Good |
| Cooperation in groups | 84% | Very Good |
| Ability to ask and answer | 76% | Good |
| Involvement in solving problems | 81% | Very Good |
| Presentation of discussion results | 78% | Good |
| **Average** | **79%** | **Good** |

## DISCUSSION

This study examined students' mathematical modelling achievement, responses, and classroom participation following the implementation of Problem-Based Learning (PBL) integrated with scaffolding and supported by equation-board media in the teaching of the Two-Variable Linear Equation System (SPLDV). Students demonstrated good mathematical modelling abilities, highly positive responses toward the learning process, and good participation during classroom activities. These results suggest that, after the instructional intervention, students were able to comprehend contextual problems, formulate them into mathematical models, carry out the required mathematical procedures, and engage actively in classroom learning activities.

The mathematical-modelling ability test results revealed that the students achieved an average score within the good performance category. Although students' mathematical modelling achievement was categorized as good, several stages of the modelling process remained challenging. Based on the indicator analysis, students still experienced difficulties in interpreting and rechecking the obtained solutions according to the original contexts of the problems. In addition, some students encountered challenges in identifying variables and formulating mathematical relationships from contextual situations. These findings suggest that mathematical modelling involves complex cognitive processes that require students to connect contextual information with mathematical representations systematically. This result suggests that the majority of students were capable of comprehending contextual situations and expressing them through suitable mathematical representations. During the learning activities, students were guided to identify relevant information, establish assumptions, develop mathematical models, determine solutions, and relate the obtained results back to the context of the given problems. These learning experiences supported the development of students' conceptual understanding and helped them establish meaningful connections between mathematical concepts and situations encountered in everyday life.

The findings related to mathematical modelling abilities are consistent with the perspective of (Lindl et al., 2025), who explained that mathematical modelling involves several interconnected processes, including understanding contextual situations, simplifying information, formulating mathematical representations, solving mathematical models, and interpreting solutions. During the learning process, students experienced these modelling processes systematically through contextual investigations and collaborative discussions. As a result, students came to recognize that mathematics extends beyond the use of formulas and procedural techniques, serving instead as a means of representing situations and addressing problems encountered in real-life contexts.

Based on the indicator analysis, understanding contextual problems achieved the highest percentage and was categorized as very good. This result demonstrates that the majority of students could recognize the information provided in the problems and identify the aspects that needed to be determined from the given contexts. Their abilities to simplify problems, establish relevant assumptions, formulate mathematical models, and solve the resulting models were also classified as good. These results suggest that most students were capable of translating contextual information into appropriate mathematical representations and selecting suitable strategies to obtain solutions to the formulated models. However, the indicator of interpreting and re-checking the obtained results achieved the lowest percentage, although it remained within the good category. Several students were still not accustomed to re-examining their solutions and interpreting mathematical results according to the original contexts of the problems. Similar observations were reported by (Siller et al., 2023), who found that students often experience difficulties in explaining and validating solutions obtained from contextual mathematical situations.

The integration of contextual problem-solving activities, adaptive scaffolding, and the use of concrete learning media may explain the good category achieved in students' mathematical modelling abilities. Through Problem-Based Learning, students were encouraged to investigate contextual situations collaboratively, identify information, formulate assumptions, and actively construct mathematical understanding. According to Hmelo-Silver, Problem Based Learning promotes active learning by engaging students in collaborative investigations and knowledge construction. Likewise, recent studies have shown that Problem Based Learning improves students' mathematical reasoning, problem-solving abilities, and learning engagement because students are directly involved in analysing and solving contextual problems (Lusiana et al., 2021; Permatasari & Marlina, 2023). These findings are also consistent with the meta-analysis, which demonstrated that Problem Based Learning significantly improves students' mathematical reasoning abilities. Therefore, the findings indicate that students engaged in mathematical modelling activities through contextual investigations, collaborative discussions, teacher guidance, and the use of equation-board media during the instructional process.

Besides the characteristics of Problem Based Learning, the scaffolding component within the instructional package provided students with guidance through questions, prompts, explanations, and feedback during the learning process. Throughout the learning process, teachers provided gradual assistance through guiding questions, prompts, explanations, and feedback according to students' learning needs. Such support enabled students to identify information, establish relationships among variables, and formulate mathematical representations more systematically. According to (Vygotsky, 1978), learning can develop optimally when students receive assistance that corresponds to their Zone of Proximal Development. Similar findings were reported by (Putri et al., 2024), who found that scaffolding strategies integrated into Problem-Based Learning improve students' mathematics achievement because gradual assistance helps students organize information systematically and develop independent problem-solving skills. Likewise,(Alaiya et al., 2024; Siller et al., 2023) explained that adaptive scaffolding strategies facilitate students in organizing information systematically, establishing conceptual relationships, and developing mathematical reasoning progressively. These findings are also supported by (Mohamad Salam et al., 2024), who reported that integrating scaffolding techniques within Problem-Based Learning environments significantly improves students' mathematical problem-solving abilities because gradual assistance helps students organize information and solve problems more independently. This result is also in line with previous studies showing that scaffolding combined with PBL not only enhances problem-solving skills but also increases students' engagement, critical thinking, and collaboration during learning activities (Tazkia & Siswono, 2023; Trisnawati & Mahmudi, 2024).

Another component implemented during the instructional process was the use of equation-board media, which provided students with opportunities to visualize relationships among variables and equations more concretely and systematically. The implementation of this media provided students with opportunities to visualize relationships among variables and equations more concretely and systematically. The use of equation-board media within the instructional package provided opportunities for students to visualize relationships among variables and equations during mathematical modelling activities. These findings are consistent with those reported by Nugraha et al. (2023) explained that the integration of Problem Based Learning with interactive learning media can improve students' understanding and participation during mathematics instruction.

The results of the student response questionnaire showed that students demonstrated highly positive perceptions toward the implemented learning process. Students perceived that learning became more enjoyable, the material was easier to understand, and they were more actively involved in classroom activities. Positive responses toward learning activities were associated with students' opportunities to collaborate, exchange ideas, and investigate contextual problems during group discussions. This finding is supported by Lusiana et al. (2021), who reported that student-centred learning environments emphasizing active participation and contextual problem solving can improve students' motivation, cognitive engagement, and academic achievement. Similarly, Wakhidah & Winarti (2024) found that students participating in PBL demonstrated higher motivation and better mathematical problem-solving abilities.

The favorable responses expressed by the students were also evident in their involvement during classroom activities. This result suggests that positive perceptions of the learning experience can foster greater student engagement and confidence when carrying out mathematical investigations. Students who viewed the learning activities as interesting and meaningful were more inclined to contribute to discussions, work collaboratively with their peers, and take part in activities involving the solution of contextual problems. The observation results indicated that students demonstrated good participation throughout the learning process. Although students' responses toward the instructional implementation reached a very good category (89%), classroom participation was classified as good (79%). This difference suggests that positive perceptions of learning did not always correspond to consistently high observable participation during classroom activities. Some students expressed enthusiasm toward the learning process but still encountered difficulties in actively participating in discussions, constructing mathematical models, and communicating their ideas. Students actively engaged in discussions, collaborated with their group members, asked and answered questions, and participated in solving contextual problems. Student participation increased when they used the equation board media and presented the results of their discussions.

The active classroom atmosphere identified in this study aligns with the fundamental characteristics of Problem-Based Learning (PBL), which places emphasis on collaborative work, inquiry, and the development of knowledge through learning experiences. Activities that provide opportunities for students to express mathematical ideas and exchange different approaches to solving problems can foster greater engagement and strengthen students' confidence throughout the learning process. Comparable results were also documented by Lusiana et al. (2021), who concluded that collaborative and student-centred learning environments significantly improve students' participation and engagement during instruction.

Taken together, the findings provide an overall account of students' mathematical-modelling achievement, responses, and classroom participation after the implementation of Problem-Based Learning (PBL) integrated with scaffolding and supported by equation-board media. The learning process not only emphasized obtaining final answers but also helped students understand mathematical modelling processes through contextual investigations, collaborative discussions, adaptive teacher support, and the use of concrete learning media. The results of this study offer further insight into the application of Problem-Based Learning (PBL) integrated with scaffolding and supported by equation-board media in teaching the Two-Variable Linear Equation System (SPLDV).

## CONCLUSION AND SUGGESTIONS

The implementation of Problem-Based Learning (PBL) combined with scaffolding and supported by equation-board media in teaching the Two-Variable Linear Equation System (SPLDV) resulted in generally good mathematical-modelling performance among the participating students, as indicated by a mean score of 80. The students also demonstrated highly positive responses to the learning process. Furthermore, their participation and involvement throughout the classroom activities were classified as good. These descriptive findings suggest that the instructional package is promising for SPLDV learning and that students were able to engage in mathematical-modelling activities, collaborate with their peers, and participate actively in classroom learning following the instructional implementation.

Nevertheless, because this study employed a single-group posttest-only design involving only one class and a relatively short implementation period without a pretest or comparison group, no conclusion can be drawn regarding improvement or causal effectiveness. Moreover, this study was conducted specifically on the topic of SPLDV and included a limited number of participants. Future research is therefore encouraged to adopt more robust research designs, including pretest–posttest designs with comparison groups, and to involve larger samples with greater diversity. Further studies should also utilize validated research instruments, examine students' performance at the level of individual indicators, and explore the processes underlying mathematical modelling through qualitative approaches. Such investigations may be extended to various mathematical topics and conducted in different educational settings to provide broader and more comprehensive findings.

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