p-ISSN: 2086-4280
e-ISSN: 2527-8827

Analyzing Students' Problem-Solving Skills in a Project-Based STEM Learning Environment on Systems of Linear Equations

Fathimatuz Zahrah[1], Somakim[2*]

Mathematics Education, Universitas Sriwijaya
Jalan Srijaya Negara, Bukit Lama, Ilir Barat I, Palembang, South Sumatera, Indonesia
[2*]somakim@fkip.unsri.ac.id

Article received: 15-05-2025, revision: 22-06-2025, published: 30-07-2025

Abstrak

Pemecahan masalah merupakan fondasi pembelajaran matematika yang menuntut siswa untuk mengembangkan ide-ide matematis guna menyelesaikan berbagai bentuk permasalahan, khususnya di era Revolusi Industri 4.0 dan Society 5.0. Pembelajaran Project-Based Learning yang diintegrasikan dengan Science, Technology, Engineering, and Mathematics (PjBL-STEM) memberikan peluang bagi siswa untuk mengembangkan kemampuan tersebut. Penelitian ini bertujuan untuk menelaah kemampuan pemecahan masalah siswa pada materi Sistem Persamaan Linear Tiga Variabel (SPLTV) dengan menggunakan model PjBL-STEM. Penelitian ini menerapkan desain metode campuran sekuensial eksplanatori (sequential explanatory mixed-method) dan menggunakan teori tahapan pemecahan masalah George Polya. Teknik pengumpulan data yang digunakan meliputi observasi, tes tertulis, dan wawancara. Analisis data dilakukan secara kuantitatif yang dilanjutkan dengan analisis kualitatif. Hasil penelitian ini diharapkan dapat memberikan informasi terkait profil kemampuan pemecahan masalah siswa melalui model PjBL-STEM pada materi Sistem Persamaan Linear Tiga Variabel.
***Kata Kunci**: Kemampuan pemecahan masalah; PjBL-STEM; Sistem Persamaan Linear Tiga Variabel; Teori Polya; metode campuran.*

Abstract

Problem-solving constitutes the foundation of mathematics learning, requiring students to develop mathematical concepts to address diverse problems, particularly within the context of Industry 4.0 and Society 5.0. Project-Based Learning integrated with Science, Technology, Engineering, and Mathematics (PjBL-STEM) offers a strategic framework to foster these skills. This study aims to analyze students' problem-solving abilities regarding Systems of Linear Equations in Three Variables using the PjBL-STEM model. The research employs a sequential explanatory mixed-method design, utilizing Polya's problem-solving framework. Data were collected through observations, written tests, and interviews. The data were then analyzed quantitatively, followed by qualitative interpretation. The findings of this study are expected to provide significant insights into students' problem-solving profiles under the PjBL-STEM model in the topic of linear equations.
Keywords: Problem-solving skills; PjBL-STEM; Systems of Linear Equations in Three Variables; Polya’s theory; mixed-method design.

I. INTRODUCTION

The Merdeka Curriculum, Indonesia's latest education system, was designed to address the challenges of the Industrial Revolution 4.0 and Society 5.0 eras (Ghassani et al., 2023; Haryati et al., 2022; Lase, 2019). Society 5.0 itself is a direct result of the Industrial Revolution 4.0. This era is characterized by continuously integrating the virtual and physical worlds (Alam, 2019; Duskri, Afrizal, & Susanti, 2024). The central concept of Society 5.0 focuses on solving social problems by integrating digital technology into every aspect of life to improve work efficiency and effectiveness (Bungawati, 2022; Fariji et al., 2025). In line with the demands of 21st-century skills, society 4.0, in preparation for society 5.0, is required to possess problem-solving and creative thinking skills to meet various real-world challenges (Lase, 2020; Halini et al., 2023; Utari et al., 2024).

In the field of education, students' problem-solving ability is highlighted as a fundamental skill in learning (Suryani et al., 2020; Astuti, 2024). Specifically in mathematics education, problem-solving is considered the heart of mathematics (Güner & Erbay, 2021; Suprihatiningsih et al., 2025). This is reinforced by the National Council of Teachers of Mathematics (NCTM), which states that mathematics education should aim to strengthen students' problem-solving skills. Many mathematical skills involve problem-solving, making it a key focus in the assessment of learning (Al-Mutawah et al., 2019; Faturohman & Afriansyah, 2020). According to (Fitriani & Budiman, 2022), the role of problem-solving in mathematics education is threefold: (1) it is a general goal of mathematics education; (2) the procedural, methodical, and strategic skills involved in problem-solving are critical processes in the mathematics curriculum; and (3) problem-solving is one of the basic skills in learning mathematics. Furthermore, this skill is essential because once students master it, they gain personal experience that guides them to apply these skills in their daily lives (Elita et al., 2019; Talia, Afriansyah, & Sumartini, 2024).

One of the reputable organizations that measures students' abilities internationally is the OECD (Organisation for Economic Co-operation and Development) through its Programme for International Student Assessment (PISA) (Masfufah & Afriansyah, 2021). PISA 2022 defines mathematics as students' ability to reason mathematically with the aim of solving problems in various real-world contexts (OECD, 2023b). According to the latest data released from PISA 2022, the average score of Indonesian students was 366, which is 106 points lower than the OECD average. Of the six proficiency levels in mathematics, approximately 80% of Indonesian students were at or below Level 1, with 14% at Level 2. This means only 6% of students reached Level 3 or higher. This score places Indonesia in the bottom 12 out of 81 countries (OECD, 2023).

Figure 1. Indonesia's Ranking in PISA 2022.

The results of this assessment indicate that students' mathematical abilities, particularly in problem-solving, are still relatively low (Pitriyani & Afriansyah, 2023; Maharani & Cesaria, 2024). They are not yet capable of planning appropriate strategies to solve even simple mathematical problems.

One mathematical domain closely related to problem-solving is algebra. PISA categorizes algebra under the content area of "change and relationships." Algebra itself involves the study of symbols, numbers, and the methods of manipulating them. Its topics range from arithmetic operations, problem-solving procedures, relationships between quantities, to more abstract algebraic structures. Many mathematical domains require algebra to solve their problems, which is why algebra remains a core topic in mathematics, especially in secondary school, as it is essential for understanding other subjects (Pramesti & Retnawati, 2019). Algebra topics in secondary school typically cover equations and inequalities, from linear, quadratic, and polynomial equations to systems of equations like systems of linear equations in two and three variables.

Several previous studies have explored students' problem-solving abilities in solving problems related to Systems of Linear Equations in Three Variables (SPLTV). Most student learning outcomes tend to fall in the medium or low categories. This is due to students being unaccustomed to the planning process, as they are often used to working directly on problems without first planning their approach (Asok & Hasanah, 2021). Additionally, students struggle to summarize the given information, which leads to frequent errors during the data manipulation process, particularly when inputting known information into mathematical forms (Wahyuni et al., 2023). Students also often lack precision in calculations, leading to incorrect answers (Cahirati et al., 2020).

One approach to addressing students' low problem-solving skills is by implementing an appropriate learning model. STEM learning integrates Science, Technology, Engineering, and Mathematics into a learning process that provides students with a holistic learning experience (Mulyani, 2019). STEM education’s goal is to enable students to develop science and technology literacy, reflected through activities such as reading, writing, observing, and conducting scientific inquiries. This way, when students enter society, they will be able to apply the competencies they have developed to solve real-life problems related to STEM fields (Mu'minah & Aripin, 2019). Several previous studies have shown that STEM learning is effective in improving students' problem-solving abilities, with STEM having a more significant impact on student performance compared to conventional learning (Astuti et al., 2021; Lathiifah & Kurniasi, 2020).

Project-Based Learning (PjBL) integrated with STEM (Science, Technology, Engineering, and Mathematics) offers a strategic approach to overcome these challenges. According to Djam'an et al., the integration of PjBL with the STEM approach is effective in fostering students' mathematical understanding through contextual and collaborative project-based activities (Djam'an et al., 2025). In the context of Mathematics, specifically Systems of Linear Equations in Three Variables (SPLTV), students often struggle with abstract variables (x, y, z). PjBL-STEM bridges this gap by providing a concrete context—such as nutritional analysis or engineering design—where variables represent tangible quantities. This contextualization is crucial because, as emphasized by Nguyện et al., integrating design thinking into STEM education significantly enhances students' ability to apply abstract STEM knowledge into practical solutions, thereby reinforcing their problem-solving skills and self-evaluation capabilities (Nguyện et al., 2025).

Many previous studies have examined the effects of project-based learning on the topic of systems of linear equations in three variables. Some have also explored the impact of Problem-Based Learning (PBL) integrated with STEM on students' mathematical problem-solving skills in the context of systems of linear equations in three variables. However, the application of PjBL-STEM to this topic is still relatively rare.

Although numerous studies have highlighted the effectiveness of PjBL-STEM on students' learning outcomes, limited research has specifically analyzed the cognitive process of students during the intervention, particularly using Polya's problem-solving framework on SPLTV material. Most existing studies focus on the final score achievement without dissecting how students form mathematical models from engineering contexts. Therefore, this study is necessary to provide a granular analysis of students' difficulties and strengths at each stage of problem-solving (Understanding, Planning, Solving, and Looking Back) within a STEM-based learning environment.

Based on the explanation above, this study aims to examine students' mathematical problem-solving abilities using the PjBL-STEM model in the topic of Systems of Linear Equations in Three Variables (SPLTV). This research is expected to serve as a reference while also expanding the knowledge network and insights related to the PjBL-STEM model and its implications for problem-solving abilities in the context of Systems of Linear Equations in Three Variables (SPLTV).

II. Method

This study employed a Sequential Explanatory Mixed-Method design, combining quantitative and qualitative approaches to provide a comprehensive

p-ISSN: 2086-4280
e-ISSN: 2527-8827

analysis of students' problem-solving skills (Waruwu, 2023). The quantitative phase aimed to categorize students' abilities based on test scores, while the qualitative phase involved in-depth interviews to investigate the cognitive processes and specific difficulties encountered during problem-solving.

The research was conducted at SMA Negeri 1 Palembang involving 30 students from Class X.6 during the odd semester of the 2024/2025 academic year. The subjects were selected using a purposive sampling technique based on the criteria that they had received the specific PjBL-STEM intervention on the topic of Systems of Linear Equations in Three Variables (SPLTV).

The study began with the preparation stage, involving the development of the learning module and research instruments (test and interview guide), which were validated by experts.

The implementation stage was the core of this study, where the PjBL-STEM model was applied. The learning process followed the STEM project syntax: Reflection, Research, Discovery, Application, and Communication (Asri, 2020). In this study, the project theme was "Smart Nutrition, Smart Budget." Students were challenged to create a wall magazine poster (mading) that educated peers about daily nutritional needs. The complexity of the project required students to use SPLTV to calculate a balanced menu that met nutritional standards (Science) while adhering to the constraints of the average student's daily pocket money (Mathematics/Engineering constraints). The final posters were displayed on the school/class bulletin board as an educational resource.

Following the intervention, a written test was administered. Based on the test results, students were grouped into three categories (High, Medium, Low) using the criteria in Table 1 (Rambe & Afri, 2020).

Table 1.
Categories of Problem-Solving Abilities

Category	Problem-Solving Ability Achievement
High	$N > 70\%$
Medium	$55\% < N \leq 70\%$
Low	$N \leq 55\%$

From the categorized data, three specific subjects were selected for in-depth interviews using a purposive sampling technique. These subjects were: Subject 1 (High Ability), Subject 2 (Medium Ability), and Subject 3 (Low Ability). The selection was based on specific criteria: (1) the subject's written test score represented the typical characteristics of their respective category, (2) the diversity of errors or strategies displayed in their answers, and (3) their communication skills, ensuring they could articulate their thinking process clearly during the interview. The qualitative data were analyzed based on George Polya's problem-solving indicators in the book Keterampilan Dasar Mengajar (Aminah & Wahyuni, 2019): (1) Understanding the problem, (2) Devising a plan, (3) Carrying out the plan, and (4) Looking back. The alignment of these indicators with the research instrument is presented in Table 2.

Table 1.
Problem-Solving Ability Indicators

Step	Problem Solving	Indicator
1	Understanding the problem	• Students identify what is known and what is being asked

Step	Problem Solving	Indicator
		in the problem.
2	Devising a plan	• Students determine appropriate strategies or methods for solving the problem, such as identifying formulas. • Students outline a plan and steps to solve the problem.
3	Carrying out the plan	• Students follow the planned steps to solve the problem. • Students follow the planned steps to solve the problem.
4	Looking back	• Students review their completed work. • Students verify the correctness of their answers

III. Result and Discussion

The learning process was conducted over two sessions, each lasting 45 minutes. The lessons took place in class X.6, with the researcher acting as the instructor using the PjBL model integrated with STEM learning. The researcher began the lesson with an introduction by leading a prayer and checking attendance, followed by an initial question (aperception) and stating the learning objectives.

In the first session, four PjBL-STEM syntax stages were implemented: Reflection, Research, Discovery, and Application. The reflection stage guided students into the context of the problem, connecting what is known with what students need to learn. During this stage, students listened to explanations about the importance of planning a food budget using SPLTV. Next, students were divided into small groups and asked to discuss daily nutritional needs and the importance of balanced meals as part of their science learning.

In the research stage, students worked in groups to identify three food items and gather information related to their nutritional content and prices as data. The discovery stage encouraged them to use the existing data to form a system of linear equations with three variables. Finally, in the application stage, students solved the system of linear equations and determined the optimal amount of each food item according to the required nutrition.

The fourth stage continued into the second session, where students designed a daily meal plan that met nutritional needs within the given budget, presented in the form of a poster. After designing their posters, in the fifth stage (communication), they presented their group work results.

After completing the two sessions, students were given a written test consisting of two open-ended questions to assess their mathematical problem-solving abilities related to the topic of systems of linear equations in three variables. The questions were formulated based on problem-solving ability indicators and had been validated by an expert reviewer. The test questions used are presented in Figures 2 and 3.

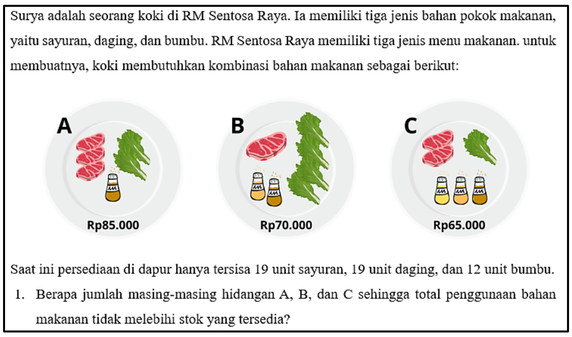


Figure 2. Question Number 1.

Figure 3. Question Number 2.

Students' test scores are determined by assigning points to each student's answer according to the scoring rubric that has been established. The scores are then converted into a grading scale (0-100) based on the following criteria (Rambe & Afri, 2020) (see Figure 4).

$$N = \frac{R}{SM} \times 100\%$$

Description:
N : *Problem solving ability achievement*
R : *Total score*
SM : *Maximum score*

Figure 4. Score Criteria.

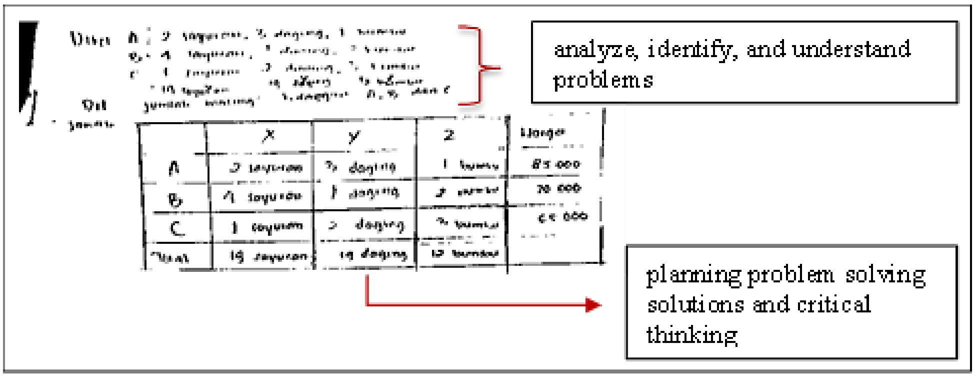
Students' test scores are grouped according to the predetermined grading scale. The researcher selects research subjects based on their problem-solving ability scores measured using the score intervals from each category. The categories of students' problem-solving abilities can be seen in Table 3.

Table 3.
Problem solving ability categories

Categories	Problem Solving Ability Achievement	Number of students
High	$N > 70\%$	12
Medium	$55\% < N \leq 70\%$	10
Low	$N \leq 55\%$	8

Subjects were selected by choosing one individual from each category with different abilities. This selection of research subjects was conducted to analyze the emergence of indicators from each category descriptively and qualitatively. One student with high ability was selected as subject H1, one student with medium ability was selected as subject M1, and one student with low ability was selected as subject L1. The problem-solving abilities of students in each category are described as follows.

H1 successfully solves problems in the questions, as evidenced by the answers provided, which meet all four indicators of problem-solving ability. The answer for question number 1 from subject H1 can be seen in Figure 5.



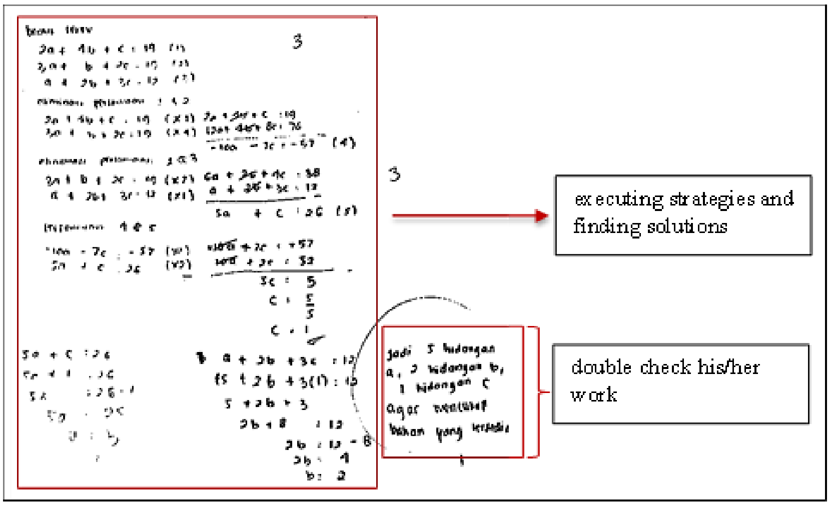


Figure 5. Answer from Subject H1 for Question 1.

Based on the answer from H1 for question 1, H1 has managed to respond to the problem completely and accurately. The steps taken were in accordance with the procedures and indicators of mathematical problem-solving. Firstly, H1 identified what was known and what was being asked in the given problem. In the second step, H1 modeled the problem in the form of a table as a strategic plan. Additionally, H1 wrote the strategic plan in text form, such as "form of SPLTV" and "elimination of equations." In the planning stage, H1 demonstrated strong mathematical fluency by immediately selecting a mixed method (elimination-substitution). The interview implies that H1 had a structured mental model of the solution before starting calculations, a skill honed through the systematic thinking required in the Engineering design process of the project

However, in the planning process, H1 did not fully detail the substitution of equations. H1 proceeded to perform the substitution without first writing down the plan. This was further clarified in the interview process with the subject. Below are the results of the interview between the researcher and H1.

Q : *How do you determine the form of SPLTV in the first question?*

H1 : *I made it based on the table that I formed using data vertically*

Q : *What about your strategy in solving the system of equations?*

H1 : *I used a mixed method, namely with the elimination stage and then substitution, but on the answer sheet, I forgot to provide information on substitution*

The interview excerpt confirms that H1 did not face calculation errors. This consistency suggests that the project's requirement to produce a valid final product (a balanced menu) motivated H1 to perform calculations meticulously.

In the next step, H1 implemented the strategy to find a solution to the given problem, as evidenced by the careful and accurate work process, resulting in a correct answer. In the final step, H1 provided a conclusion at the end of the problem-solving process, indicating that they had reviewed their work. Therefore, for question number 1, H1 has met the indicators of understanding the problem, planning the strategy, executing the strategy, and reviewing the results. In question number 2, H1 was also able to answer accurately and comprehensively. The answer for question number 2 from subject H1 can be seen in Figure 6.

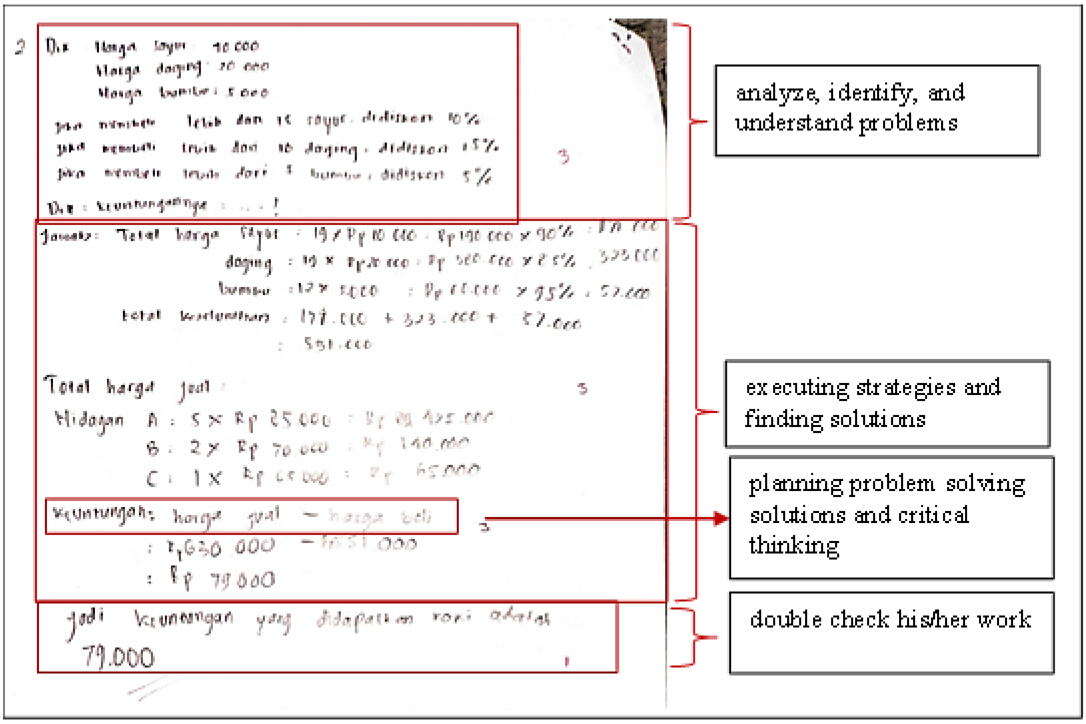


Figure 6. Answer from Subject H1 for Question 2.

H1 completed question 2, as shown in the image, effectively and meticulously. All indicators of problem-solving ability are evident in the worksheet. For understanding the problem indicator, H1 was able to accurately present what was known and what was being asked. The strategic plan is visible through the written text, such as "total price" and mentioning the formula for calculating profit. In the third step, H1 executed the strategy well, resulting in the correct answer. Unlike subjects in the lower categories, H1 performed the 'Looking Back' stage effectively. H1 verified the final values by substituting them back into the equations, ensuring the nutritional targets were met. This reflects a high level of metacognitive awareness fostered by the PjBL reflection phase.

Based on the answer written by M1 in Figure 7, M1 demonstrated a good understanding of the mathematical procedures but showed inconsistencies in processing information. In Question 1, regarding the menu planning based on kitchen stock, M1 successfully identified the variables (Dishes A, B, and C). However, M1 failed to write down the known information completely. The interview revealed that M1 focused too heavily on the visual data (images of ingredients) and overlooked the textual constraints in the problem. This suggests a challenge in multimodal literacy—a crucial skill in STEM where students must integrate data from various sources (text, diagrams, and labels).

Despite this, M1 successfully used a table to model the linear equation system. This indicates that M1 possesses systematic thinking skills (Engineering), allowing M1 to organize the scattered stock data into a structured mathematical model. M1 executed the elimination-substitution strategy correctly and found the values A=5, B=2, and C=1

However, a critical gap appeared in the final stage ("Looking Back"). M1 did not provide a conclusion for Question 1. Although the calculation was correct, M1 failed to translate these numbers back into the context of the Chef's needs (e.g., "The stock is sufficient to cook 5 portions of Dish A..."). This implies that M1 still views the task as a purely Mathematical calculation rather than a Contextual problem-solving task. In a complete PjBL-STEM approach, the mathematical result must be interpreted to answer the real-world problem.

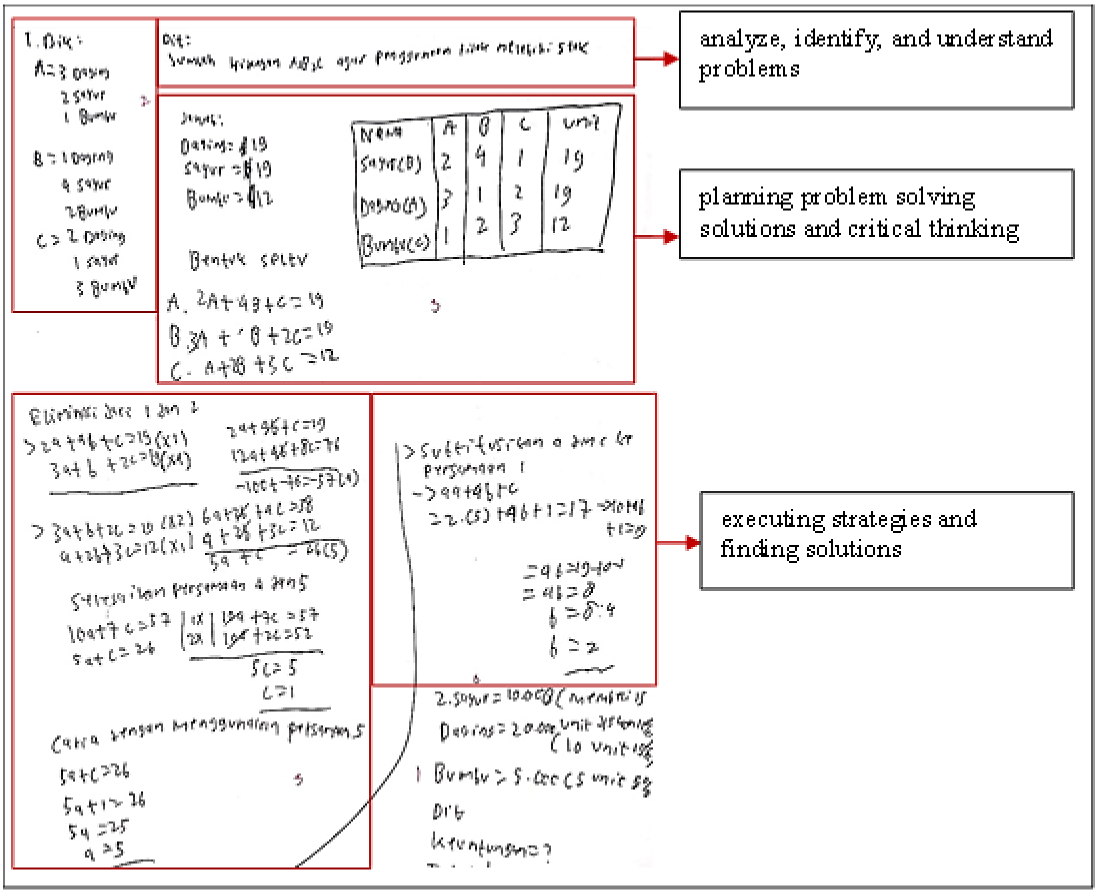


Figure 7. Answer from Subject M1 for Question 1.

The interview results below provide further insight into M1's cognitive process:

P : *Pay attention to what is known from the given question, what do you think is lacking from the results of the work that you have written?*

M1 : *In the known section, I have not included information on the amount of ingredients*

P : *What are your obstacles in writing the known section?*

M1 : *I was too focused on the information in the picture that I forgot the information in the text, so I have written it again in the problem-solving section*

P : *Then, what are the results of question number 1?*

M1 : The result is through the SPLTV the value of A = 5, B = 2 and C = 1

P : So, what is meant based on these results?

M1 : This means that we can make 5 dishes of A, 2 dishes of B, and 1 dish of C

In Question 2, M1 made an error in presenting the known information due to a lack of synchronization between the written text and the problem data. Furthermore, M1 skipped the "Devising a Plan" stage entirely (did not write the formula/strategy). The answer to the second question from subject M1 can be seen in Figure 8.

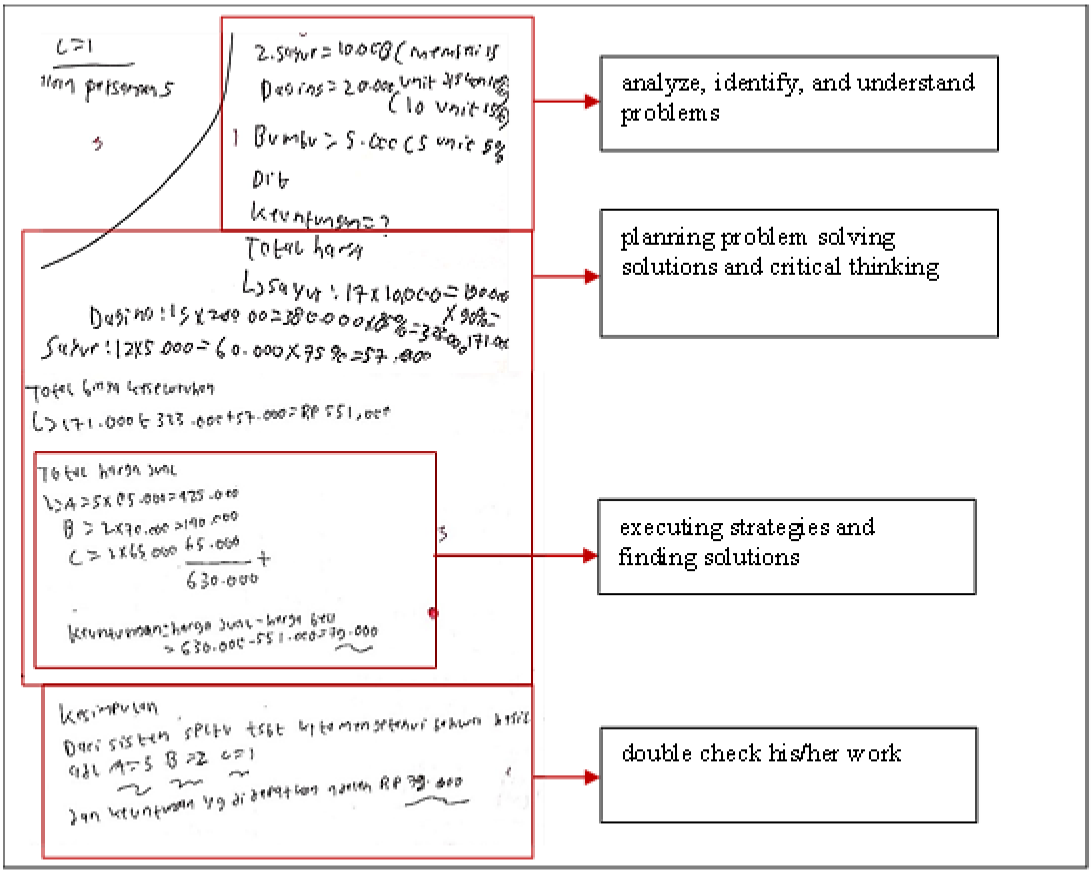


Figure 8. Answer from Subject M1 for Question 2.

The interview clarified the reason for this omission:

Q : What obstacles did you face in Question 2?

M1 : I was in a hurry, so I immediately wrote down the calculations without writing down the strategy used.

This statement highlights a significant finding: M1's failure was not due to a lack of mathematical knowledge (as the calculations were correct), but due to a lack of self-regulation under pressure. In the context of STEM project management, this reflects a struggle with working within constraints (time limits). While M1 has strong procedural fluency, the metacognitive habit of planning before acting—which is essential in Engineering Design—collapsed when M1 felt rushed. Unlike subject H1 who remained structured, M1 prioritized speed over process, leading to a less organized solution.

The answers written by L1 in Figure 8 indicate fundamental difficulties in transitioning from the concrete problem context to the abstract mathematical model. In the "Understanding the Problem" stage, L1 attempted to write down the known information based on the Chef's kitchen stock data. However, L1 failed to translate the visual data (pictures of ingredients) into distinct variables (x, y, z). L1 merely copied parts of the question text without defining what the variables represented. This suggests that while the PjBL context (Science/Contextual aspect) helped L1 engage with the problem initially, L1 lacked the mathematical modeling skills required to bridge the real-world scenario with algebraic symbols.

Consequently, L1 failed completely in the "Devising a Plan" stage. There was no strategy written for solving the linear equation system. Unlike subject H1 who visualized a solution path, or M1 who attempted a strategy despite being rushed, L1 appeared to face a cognitive block. The complexity of coordinating three variables simultaneously overwhelmed L1's working memory, preventing the formulation of a solution plan.

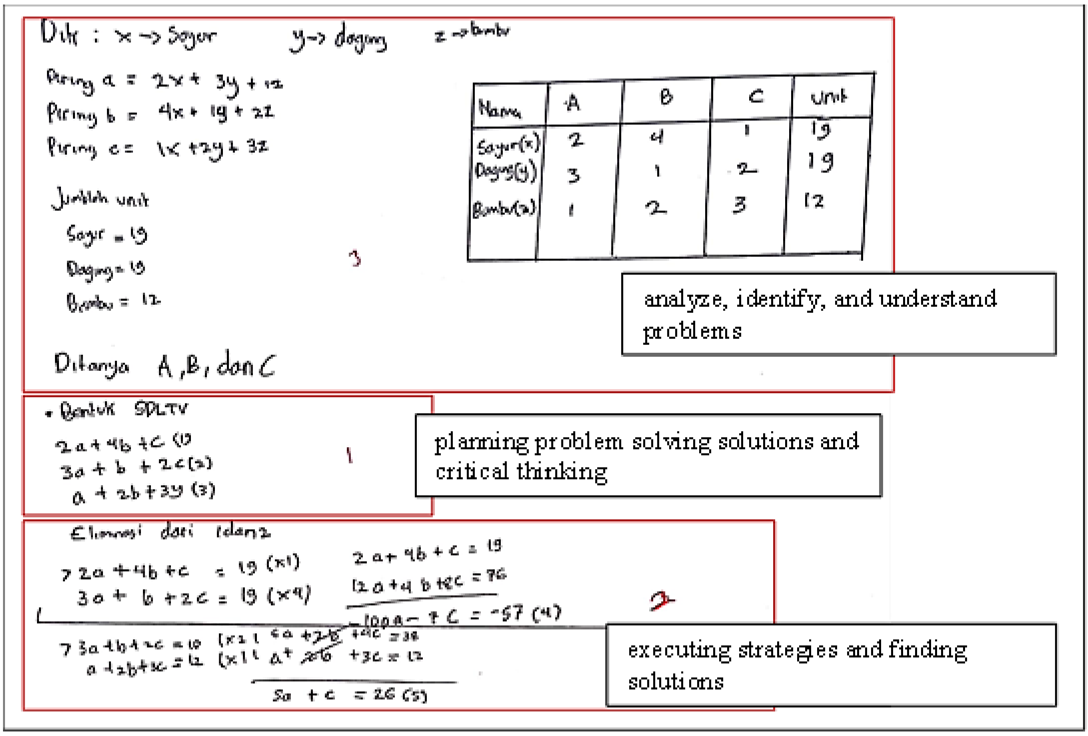


Figure 9. Answer from Subject L1 for Question 1.

The interview results below confirm that the obstacle was conceptual rather than just procedural:

Q : *How do you determine the known information?*

L1 : *I wrote down the information in the question, but my answer is still not quite right*

Q : *What are the obstacles?*

L1 : *I am not focused and do not read carefully*

Q : *What is your strategy for solving these questions?*

L1 : *Number 1 is solved by elimination and substitution, but I have not mastered how to do substitution. Number 2 is solved by* *subtracting the selling price from the purchase price.*

Q : *What obstacles do you face?*

L1 : *I am confused about how to substitute many equations, and I do not have time to include the conclusion of the question given.*

Unlike Question 1 where L1 faced a conceptual block, L1 showed improvement in Question 2. L1 was able to identify the known information and what was asked from the problem text. This indicates that L1 began to adapt to the problem-solving structure. However, despite successfully setting up the initial information, L1 still struggled to formulate the mathematical model into a solvable equation system. The answer provided in Figure 10 stops at the identification stage without a clear calculation process or conclusion.

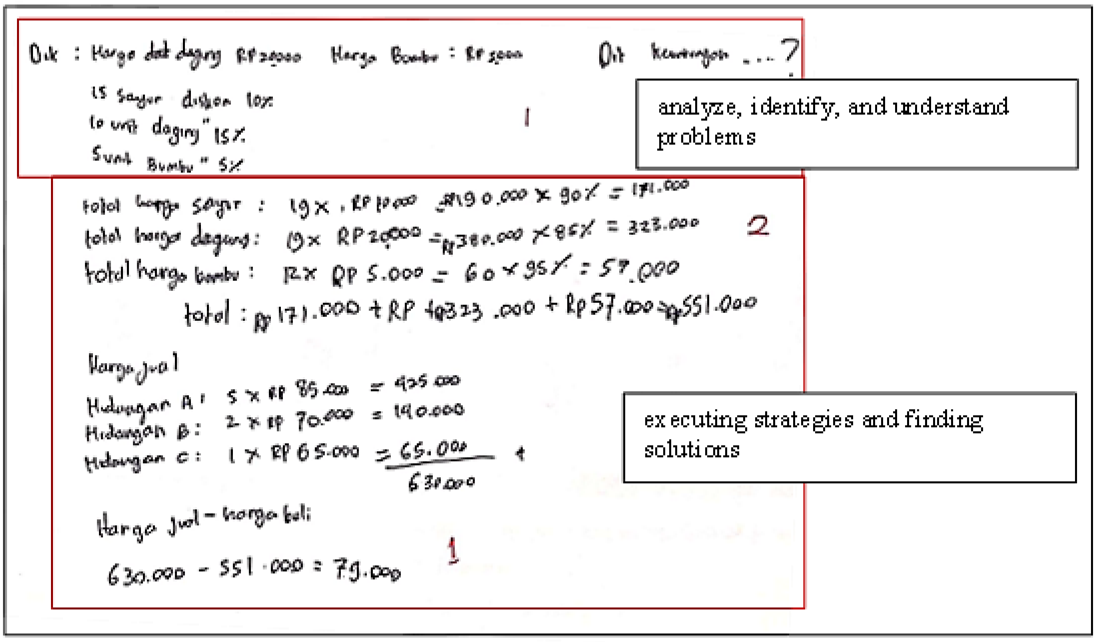


Figure 10. Answer from Subject L1 for Question 2.

This excerpt highlights a critical finding: L1's failure in "Carrying Out the Plan" was due to a lack of procedural fluency in Mathematics. Although the PjBL model provided a meaningful context, it did not automatically remedy L1's deficit in basic algebraic manipulation. The student understood the goal (helping the Chef) but did not possess the mathematical tools to achieve it.

Finally, because L1 could not reach the calculation stage, the "Looking Back" stage was naturally omitted. This indicates that for students in the Low category, the PjBL-STEM model requires additional scaffolding, particularly in the transition from Engineering design (planning the menu) to Mathematical execution (calculating the stock). Without intensive guidance on the algebraic procedures, the contextual motivation provided by STEM is insufficient for low-ability students to solve the problem independently. However, the observation showed that despite the failure in calculation, the interactive nature of the project still encouraged L1 to tackle the problems presented with more enthusiasm.

The findings generally indicate that the PjBL-STEM model successfully bridged the gap between abstract mathematical concepts and real-world applications, particularly in the Understanding the Problem stage. The high percentage of students mastering this first stage suggests that the Science and Engineering contexts (menu planning and kitchen stock management) provided a concrete mental scaffold, allowing students to visualize variables (x, y, z) as tangible items rather than meaningless symbols. This aligns with findings by Capraro et al. (2013), who noted that STEM contexts improve students' ability to represent problems. However, a divergence occurred in the subsequent stages. While High-ability students utilized the Engineering design thinking to structure their solution strategies systematically, Low-ability students struggled to transition from the contextual understanding to the procedural Mathematics execution. This implies that while PjBL-STEM is effective for conceptualization, students with lower algebraic foundations still require explicit scaffolding to handle the procedural complexity of Systems of Linear Equations.

Furthermore, the Looking Back stage was identified as the weakest aspect across the Medium and Low categories, a trend consistent with research by Purnomo et al. (Purnomo et al., 2024). The failure of Subject M1 to provide a final conclusion, despite performing correct calculations, highlights a disconnect between "doing the math" and "solving the problem." In a typical classroom setting, students often view obtaining the value of variables as the final goal. However, in a PjBL-STEM environment, the goal is to create a valid solution for the user (the Chef). The pressure of the project timeline (as seen in M1’s interview) also contributed to the omission of the verification step. Therefore, future PjBL-STEM implementations should emphasize the Reflection phase of the syntax to train students’ metacognitive skills, ensuring they verify that their mathematical answers make sense within the project's engineering constraints.

IV. CONCLUSION

Based on the analysis of problem-solving skills using the PjBL-STEM model on the Three-Variable Linear Equation System (SPLTV) material, the students were categorized into three levels: High Ability (10%), Medium Ability (56.67%), and Low Ability (33.33%). The study reveals that High-ability students demonstrated strong consistency across all four Polya stages, successfully integrating the Science context with Mathematical modeling. Medium-ability students showed competence in procedural calculations but frequently neglected the "Looking Back" stage due to a lack of metacognitive reflection. Meanwhile, Low-ability students were able to grasp the contextual problem ("Understanding the Problem") but faced significant barriers in "Devising a Plan" due to deficits in algebraic procedural fluency.

This research contributes to mathematics education by highlighting that while the PjBL-STEM model effectively aids problem representation through real-world contexts, it does not automatically remedy

p-ISSN: 2086-4280
e-ISSN: 2527-8827

fundamental algebraic weaknesses without explicit guidance. The implication is that teachers must balance the project activities with targeted scaffolding on mathematical procedures. However, this study is limited by its small sample size and focus on a single school in Palembang. Therefore, future research is recommended to involve a wider demographic and investigate specific scaffolding strategies within the PjBL syntax to better support students with lower mathematical abilities.

Acknowledgement

I would like to express my gratitude to my lecturer, math teacher and students of SMA Negeri 1 Palembang for their participation and insights during this research. Special thanks to my academic advisors for their guidance and support, as well as to my colleagues and friends for their encouragement throughout the process. I also appreciate the institutions that facilitated this study, enabling me to explore the integration of the PjBL-STEM model in mathematical problem-solving.

References

Al-Mutawah, M. A., Thomas, R., Eid, A., Mahmoud, E. Y., & Fateel, M. J. (2019). Conceptual understanding, procedural knowledge and problem-solving skills in mathematics: High school graduates work analysis and standpoints. *International Journal of Education and Practice*, *7*(3), 258–273. https://doi.org/10.18488/journal.61.2019.73.258.273

Alam, S. (2019). *Higher Order Thinking Skills (HOTS): Kemampuan Memecahkan Masalah, Berpikir Kritis dan Kreatif dalam Pendidikan Seni untuk Menghadapi Revolusi Industri 4.0 pada Era Society 5.0*.

Aminah, N., & Wahyuni, I. (2019). *Keterampilan Dasar Mengajar (Dilengkapi dengan Micro Teaching untuk Calon Guru Matematika)* (1st ed.). LovRinz Publishing.

Asok, A. N., & Hasanah, A. (2021). Senior High School Students' Mathematical Problem Solving of Three-Variable Linear Equation System. *JTAM (Jurnal Teori Dan Aplikasi Matematika)*, *5*(1), 254. https://doi.org/10.31764/jtam.v5i1.3929

Asri, N. (2020). *Penerapan Model Pembelajaran PjBL (Project Based Learning) Berbasis STEM untuk Meningkatkan Kemampuan Pemahaman Konsep Matematis Ditinjau dari Gaya Kognitif Peserta Didik* (Vol. 2507, Issue 1) [UIN Raden Intan Lampung].

Astuti, N. H., Rusilowati, A., & Subali, B. (2021). STEM-Based Learning Analysis to Improve Students' Problem-Solving Abilities in Science Subject: a Literature Review. *Journal of Innovative Science Education*, *9*(3), 79–86. https://doi.org/10.15294/jise.v9i2.38505

Astuti, S. R. (2024). Mathematical problem-solving ability of high school/vocational school students on linear programming. *Jurnal Inovasi Pembelajaran Matematika: PowerMathEdu*, *3*(1), 101–112.

https://doi.org/10.31980/pme.v3i1.1778

Bungawati. (2022). Peluang dan Tantangan Kurikulum Merdeka Belajar Menuju Era Society 5.0. *Jurnal Pendidikan*, *31*(3), 381. https://doi.org/10.32585/jp.v31i3.2847

Cahirati, P. E. P., Makur, A. P., & Fedi, S. (2020). Analisis Kesulitan Belajar Siswa dalam Pembelajaran Matematika yang Menggunakan Pendekatan PMRI. *Mosharafa: Jurnal Pendidikan Matematika*, *9*(2), 227–238. https://doi.org/10.31980/mosharafa.v9i2.606

Djam'an, N., Amaliah, N., & Arwadi, F. (2025). Pengaruh Penerapan Model PjBL dengan Pendekatan STEM Terhadap Peningkatan Kemampuan Berpikir Kreatif Matematis Siswa pada Materi Bangun Ruang Sisi Lengkung di SMP. *PROXIMAL: Jurnal Penelitian Matematika Dan Pendidikan Matematika*, *8*, 1009–1020.

Duskri, M., Afrizal, & Susanti. (2024). Analysis of Students' Mathematical Literacy in Solving Problem-Solving Questions Based on Self-Regulated Learning. *Mosharafa: Jurnal Pendidikan Matematika*, *13*(3), 575–584. https://doi.org/10.31980/mosharafa.v13i3.2180

Elita, G. S., Habibi, M., Putra, A., & Ulandari, N. (2019). Pengaruh Pembelajaran Problem Based Learning dengan Pendekatan Metakognisi terhadap Kemampuan Pemecahan Masalah Matematis. *Mosharafa: Jurnal Pendidikan Matematika*, *8*(3), 447–458. https://doi.org/10.31980/mosharafa.v8i3.580

Fariji, I., Ardianto, T., Kusmana, N., Subekhi, A. I., & Junaedi, Y. (2025). Developing a PBL–Flipped Classroom Model Based on Baduy Local Wisdom to Enhance Students' Mathematical Critical Thinking. *Plusminus: Jurnal Pendidikan Matematika*, *5*(3), 465–494. https://doi.org/10.31980/plusminus.v5i3.3240

Faturohman, I., & Afriansyah, E. A. (2020). Peningkatan Kemampuan Berpikir Kreatif Matematis Siswa melalui Creative Problem Solving. *Mosharafa: Jurnal Pendidikan Matematika*, *9*(1), 107–118. https://doi.org/10.31980/mosharafa.v9i1.596

Fitriani, A., & Budiman, I. (2022). Analisis Kemampuan Pemecahan Masalah Matematis Berdasarkan Taksonomi Bloom. *Jurnal Lemma*, *8*(2), 91–98. https://doi.org/10.22202/jl.2022.v8i2.5586

Ghassani, D. A., Nursa'adah, A., Septira, F., Effendi, M., Herman, T., & Hasanah, A. (2023). Kemandirian Belajar Siswa dalam Pembelajaran Matematika Menggunakan Kurikulum Merdeka. *Plusminus: Jurnal Pendidikan Matematika*, *3*(2), 307–316. https://doi.org/10.31980/plusminus.v3i2.1346

Güner, P., & Erbay, H. N. (2021). Prospective mathematics teachers' thinking styles and problem-solving skills. *Thinking Skills and Creativity*, *40*(April).

https://doi.org/10.1016/j.tsc.2021.100827

Halini, R, Z., Pasaribu, R. L., Mirza, A., & Afriansyah, E. A. (2023). Students' Scientific Attitudes and Creative Thinking Skills. *Mosharafa: Jurnal Pendidikan Matematika*, *12*(2), 315–326. https://doi.org/10.31980/mosharafa.v12i2.786

Haryati, L. F., Anar, A. P., & Ghufron, A. (2022). Menjawab Tantangan Era Society 5.0 Melalui Inovasi Kurikulum Merdeka Di Sekolah Dasar. *Jurnal Pendidikan Dan Konseling*, *4*(5), 5197–5202. https://doi.org/10.31004/jpdk.v4i5.7441

Lase, D. (2019). Pendidikan di Era Revolusi Industri 4.0. *SUNDERMANN: Jurnal Ilmiah Teologi, Pendidikan, Sains, Humaniora Dan Kebudayaan*, *12*(2), 28–43. https://doi.org/10.36588/sundermann.v1i1.18

Lase, D. (2020). Eksistensi Pendidikan Di Era Revolusi Industri 4.0. *Jurnal Teknologi Industri Dan Rekayasa (JTIR)*, *1*(1), 43–48. https://doi.org/10.53091/jtir.v1i1.17

Lathiifah, I. J., & Kurniasi, E. R. (2020). Analisis Kemampuan Pemecahan Masalah Siswa Pada Pembelajaran SPLDV Berbasis STEM. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *4*(2), 1273–1281. https://doi.org/10.31004/cendekia.v4i2.354

Maharani, Z., & Cesaria, A. (2024). Mathematical Problem-Solving Ability in Solving PLSV. *Jurnal Inovasi Pembelajaran Matematika: PowerMathEdu*, *3*(1), 29–36. https://doi.org/10.31980/pme.v3i1.1440

Masfufah, R., & Afriansyah, E. A. (2021). Analisis Kemampuan Literasi Matematis Siswa melalui Soal PISA. *Mosharafa: Jurnal Pendidikan Matematika*, *10*(2), 291–300. https://doi.org/10.31980/mosharafa.v10i2.662

Mu'minah, I. H., & Aripin, I. (2019). Implementasi Stem Dalam Pembelajaran Abad 21. *Prosiding Seminar Nasional Pendidikan*, *1*(2012), 1496.

Mulyani, T. (2019). Pendekatan Pembelajaran STEM untuk menghadapi Revolusi. *Seminar Nasional Pascasarjana 2019*, *7*(1), 455.

Nguyện, L. C., Hoa, H. Q., & Hien, L. H. P. (2025). Integrating design thinking into STEM education: Enhancing problem-solving skills of high school students. *EURASIA Journal of Mathematics, Science and Technology Education*, *21*(4).

OECD. (2023a). PISA 2022 Results (Volume I): The State of Learning and Equity in Education. In *Perfiles Educativos* (Vol. 46, Issue 183). OECD Publishing. https://doi.org/10.22201/iisue.24486167e.2024.183.61714

OECD. (2023b). Program For International Student (PISA) 2022 Assessment and Analytical Framework. In *OECD (Organisation for Economic Co-operation and Development) Publishing*.

Pitriyani, D. C., & Afriansyah, E. A. (2023). Middle School Mathematics Problem Solving Ability Reviewed from Students' Learning Interests. *Jurnal Inovasi Pembelajaran Matematika: PowerMathEdu*, *2*(3), 321–340. https://doi.org/10.31980/pme.v2i3.1691

Pramesti, T. I., & Retnawati, H. (2019). Difficulties in learning algebra: An analysis of students' errors. *Journal of Physics: Conference Series*, *1320*(1), 0–7. https://doi.org/10.1088/1742-6596/1320/1/012061

Purnomo, E. A., Sukestiyarno, Y. L., Junaedi, I., & Agoestanto, A. (2024). Stages of Problem-Solving in Answering HOTS-Based Questions in Differential Calculus Courses. *Mathematics Teaching Research Journal*, *15*(6), 116–145.

Rambe, A. Y. F., & Afri, L. D. (2020). Analisis Kemampuan Pemecahan Masalah Matematis Siswa Dalam Menyelesaikan Soal Materi Barisan Dan Deret. *AXIOM: Jurnal Pendidikan Dan Matematika*, *9*(2), 175. https://doi.org/10.30821/axiom.v9i2.8069

Suprihatiningsih, S., Suningsih, A., Rangkuti, R. K., Annur, M. F., & Erwin, E. (2025). Development of Geometry Problem-Solving Task Instrument to Identify Critical Thinking of Junior High School Learners. *Radian Journal: Research and Review in Mathematics Education*, *4*(4), 144–157. https://doi.org/10.35706/radian.v4i4.13207

Suryani, M., Jufri, L. H., & Putri, T. A. (2020). Analisis Kemampuan Pemecahan Masalah Siswa Berdasarkan Kemampuan Awal Matematika. *Mosharafa: Jurnal Pendidikan Matematika*, *9*(1), 119–130. https://doi.org/10.31980/mosharafa.v9i1.605

Talia, Y., Afriansyah, E. A., & Sumartini, T. S. (2024). Assessing Problem-Solving Proficiency in Mathematics: Insights from Seventh-Grade Students. *Plusminus: Jurnal Pendidikan Matematika*, *4*(2), 215–228. https://doi.org/10.31980/plusminus.v4i2.2206

Utari, R. S., Putri, R. I. I., Zulkardi, Z., & Hapizah, H. (2024). Designing Learning Trajectories to Support Prospective Teachers' Statistical Literacy Skills. *Mosharafa: Jurnal Pendidikan Matematika*, *13*(4), 877–894. https://doi.org/10.31980/mosharafa.v13i4.2546

Wahyuni, S., Julia, Ismayanti, & Saputra, E. (2023). Analysis of High School Students' Difficulties in the Material of Two Variable Linear Equation Systems. *EL-Hadhary: Jurnal Penelitian Pendidikan Multidisiplin*, *1*(01), 39–51. https://doi.org/10.61693/elhadhary.vol101.2023.39-51

Waruwu, M. (2023). Pendekatan Penelitian Pendidikan: Metode Penelitian Kualitatif, Metode Penelitian Kuantitatif dan Metode Penelitian Kombinasi (Mixed Method). *Jurnal Pendidikan Tambusai, 7*(1), 2896–2910.