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In-depth Analysis of Students' Mathematical Problem-Solving Skills: Influence Factors Motivation and Effective Teaching Strategies

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ABSTRACT

Problem-solving (PS) skills are efforts to find solutions when faced with challenges. This study aims to examine students' mathematical PS skills by focusing on the influence of learning motivation and identifying factors that were previously overlooked. A qualitative approach with a case study design was used, where the researcher acted as the primary instrument. The research also utilized PISA-type test instruments, observation sheets, and interviews. PISA-type questions were designed around content, context, and process components, adhering to the PISA framework. The study was conducted in a school in Surakarta, chosen for its alignment with the minimum competency assessment system similar to PISA. Using snowball sampling, nine students were selected for response analysis. These students were categorized based on their motivation levels: high, moderate, and low. The results show that students with high motivation are proactive in problem-solving, directly addressing the problem, reviewing each step as they proceed, and ensuring accuracy. Moderately motivated students take more time, often using scratch paper, and review their work only at the end. Low-motivation students face greater difficulties, frequently making mistakes, relying heavily on scratch paper, and often skipping the review process due to time pressure. To improve PS skills, future research could explore the integration of interactive digital tools with instant feedback, adaptive learning platforms tailored to student motivation, and collaborative learning exercises. Additionally, incorporating real-world scenarios into problem-based learning could enhance engagement and develop deeper problem-solving abilities across different motivation levels.

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1. INTRODUCTION

PS skills are a fundamental aspect of mathematics as they have a significant impact on students' development in school (Jr & Cai, 2016). PS skills not only create a strong foundation for understanding mathematical concepts but also enhance critical thinking, mathematical reasoning, and creativity (Szabo et al., 2020). Additionally, PS skills support effective mathematical communication, which is a key element in mastering the discipline of mathematics (English & Gainsburg, 2015). PS, on the other hand, is the process of finding solutions to difficult or challenging situations or questions (Dörner & Funke, 2017). In mathematics, PS involves analyzing given problems, understanding the underlying principles, and applying appropriate strategies and techniques to arrive at a solution (Johansen, 1997; Jonassen, 2000). In the educational context, mathematical PS is often manifested in the form of mathematical problems that involve the concepts taught (Jr & Cai, 2016). Students are faced with problems and are expected to find solutions by applying their mathematical knowledge.

Previous research has indicated that students' problem-solving (PS) abilities are still low. For example, Muhaimin et al. (2023) study found that students struggle to understand problem situations. Another study also revealed that the low PS ability of students is due to difficulties in identifying problems (Franestian et al., 2020). Although the importance of mathematical PS has been widely recognized in the educational context, research examining the characteristics of students' mathematical PS skills is still evolving (Lester, 2013; Pimta et al., 2009; Rahman & Ahmar, 2016; Tambychik & Meerah, 2010). Previous research has provided valuable insights into the PS process and the factors influencing it. However, there is still room for further exploration that can bring our understanding of students' mathematical PS skills to a deeper and more contextual level. For instance, many studies have concentrated on cognitive processes or instructional strategies but have not fully examined how varying levels of motivation impact problem-solving efficiency or how anxiety affects students' performance under pressure. Existing research sometimes lacks a comprehensive view of these personal and emotional factors, which are critical for understanding the complete picture of student performance. Moreover, previous studies have often used broad categories of student abilities or general problem-solving approaches, leaving out nuanced aspects like the interplay between motivation, anxiety, and problem-solving strategies. By focusing specifically on these underexplored areas, this research aims to address these gaps and provide a more detailed understanding of how motivational factors and stress influence problem-solving skills. This approach is expected to offer novel insights into the development of mathematical PS skills, leading to more effective and tailored educational strategies that consider individual differences among students.

This study aims to fill this gap by involving an in-depth analysis of the characteristics of students' mathematical PS skills. The researcher will explore various factors influencing the development of PS skills. Additionally, this study aims to identify factors that may have been overlooked in previous research (Bilah et al., 2017; Laila et al., 2021; Purnamasari & Setiawan, 2019; Utami & Wutsqa, 2017). For instance, the role of student motivation in mathematical PS skills could be an important factor that has yet to be fully understood. Likewise, the role of anxiety or stress in affecting students' mathematical PS skills will be examined. This study also seeks to identify effective strategies for developing students' mathematical PS skills. In the context of education, it is crucial to find the most effective teaching methods to help students develop PS skills.

The potential contributions of this research include providing a clearer understanding of the factors that affect students' problem-solving skills and informing the development of more effective teaching methods. By addressing these factors, the study aims to enhance educational practices and policies, ultimately improving students' ability to tackle real-world challenges that require critical thinking and problem-solving abilities. In real-world applications, the findings could help educators tailor instructional approaches to better support students' problem-solving development, preparing them more effectively for future academic and professional challenges. The study’s insights are expected to influence educational strategies and contribute to the broader goal of equipping students with the skills necessary for success in an increasingly complex world.

2. METHODS

This study employs a qualitative approach with a case study design to gain an in-depth understanding of students' problem-solving (PS) skills. The qualitative method is ideal for exploring complex and contextual aspects of PS skills, allowing for detailed analysis within a specific educational setting. The participants include 29 students from a single class at a school in Surakarta, Central Java. This selection was based on practical considerations such as accessibility and relevance to the research topic, which facilitated detailed and consistent observations. While focusing on one class provides rich, context-specific insights, it limits the generalizability of the findings. The sample size, though adequate for qualitative analysis, is relatively small and specific to this setting. Future research could expand the sample to include multiple classes or schools to capture a broader range of experiences and strategies. Observations were conducted over several sessions (45 to 60 minutes each) during regular problem-solving tasks. These observations aimed to capture how students understood, interpreted, and solved problems. Key aspects noted included their strategies, accuracy, and methods for solving problems, as well as their process for reviewing and correcting work. Field notes from these sessions provided valuable insights into students' problem-solving behaviors and strategies.

In addition to observations, students completed PISA-type test questions designed to reflect real-world scenarios requiring critical and analytical thinking. These questions, aligned with PISA standards, challenge students to apply mathematical reasoning across diverse situations. The analysis followed Polya’s problem-solving method, which included understanding the problem, devising a plan, executing the plan, and reviewing the solution. Each stage of students' responses was assessed to understand their approach and problem-solving skills comprehensively.

The snowball sampling technique was employed to select 9 out of the 29 students for interviews. This technique began with initial participants chosen based on specific criteria, such as their problem-solving skills and test performance. These participants, who either excelled or faced challenges, provided a broad spectrum of experiences. They were then asked to recommend other students who could offer additional perspectives, ensuring a diverse and representative sample. This approach aimed to capture a comprehensive understanding of various factors influencing problem-solving skills.

To ensure data validity, a source triangulation process was used. This involved cross-verifying data from multiple sources—observations, tests, and interviews. Observations provided insights into students' real-time problem-solving approaches, while test results offered a quantifiable measure of performance. Interview responses were used to gain an understanding of students' thought processes and strategies. By comparing and contrasting these data sources, the study aimed to achieve a more accurate and comprehensive understanding of students' problem-solving skills, minimizing potential biases. The data analysis process involved systematically integrating these findings to ensure robust conclusions. The data analysis techniques in this study will involve the following steps:

1. Transcription of Interviews: Interviews will be recorded, and the recordings will be carefully transcribed to ensure that all relevant information is accurately noted.
2. Data Categorization: Data from observations, tests, and interviews will be categorized according to the themes or concepts that emerge during the analysis. The data categorization process involves systematically organizing and analyzing information from observations, tests, and interviews to identify recurring themes or concepts related to students' problem-solving skills. This begins with coding, where specific data segments are labeled based on their relevance, followed by grouping related codes into broader categories that reflect underlying patterns. Themes are identified through iterative coding and are used to develop a deeper understanding of how students approach problem-solving. Potential themes might include problem understanding, strategy development, execution, and self-monitoring, all of which contribute to analyzing the effectiveness of students' problem-solving processes.
3. Content Analysis: Content analysis will be used to identify patterns or themes that emerge in the data. This will help in understanding the characteristics of students' PS skills and the factors that influence these skills. In this study, content analysis will be used to systematically examine and

interpret students' written responses, interviews, and observational notes. The data will be coded to identify specific ideas or concepts related to problem-solving, such as strategies used or difficulties encountered. By analyzing these codes, patterns and themes will emerge, revealing how factors like motivation and prior knowledge influence students' problem-solving skills. These themes will provide insights into the characteristics of effective and less effective problem-solving approaches, helping to inform instructional strategies and interventions tailored to different learning needs.

4. Drawing Conclusions: The results of the analysis will be used to formulate relevant conclusions and research findings.

Additionally, it is important to consider research ethics, such as privacy and consent from the school and the parents of the students involved. The safety and comfort of the research subjects must also be well maintained, so all data regarding the identity of the subjects and the school in this manuscript are anonymized.

3. FINDINGS AND DISCUSSION

Categorizing students' learning motivation into high, moderate, and low levels is key to understanding its effect on problem-solving skills. This classification helps reveal how motivation influences problem-solving approaches and strategies, guiding targeted interventions. The study's findings, based on the problem-solving process, highlight differences in abilities across motivation levels, as shown in Table 1. This categorization enables the development of tailored teaching methods to address varying motivational needs.

Table 1. Categories of learning motivation

Score Acquisition	Learning Motivation Category	The number of students
$92 \leq score \leq 128$	High	5
$64 \leq score < 92$	Moderate	20
$32 \leq score < 64$	Low	4

The PS process in this study follows Polya's steps (Polya, 1957), including (1) understanding the problem, (2) devising a plan to solve the problem, (3) carrying out the plan, and (4) looking back at the completeness of the solution. This study uses PISA-type mathematical problems to measure students' PS abilities. These problems have algebraic content with a social context, as shown in Figure 1.

Seorang pedagang sembako menjual minyak goreng pada 23 November 2021 dengan 3 merek yang berbeda, yaitu merek Sunmo, Bamoli, dan Fertune seharga Rp 14.000 per liter. Harga minyak goreng Bamoli pada saat ini naik 40% dari harga semula, kemudian harga minyak goreng Sunmo 5% lebih murah dari Bamoli, dan selisih harga minyak goreng Fertune dengan Bamoli dua kali selisih minyak goreng Sunmo dan Bamoli. Dari pernyataan tersebut, berapa harga masing-masing minyak goreng saat ini?

Figure 1. PISA type problems

3.1. Understanding the Problem

This process examines how students understand the information before solving the problem. Subjects with high learning motivation begin by reading the problem and then writing down all important information on their answer sheet (Figure 2). In this situation, the subject shows no signs of difficulty in identifying the problem.

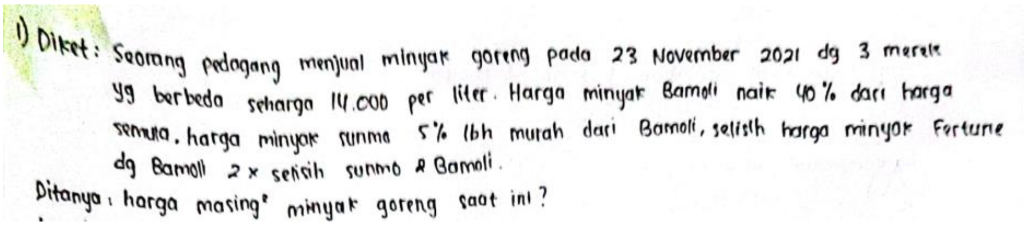
1) Diket: Seorang pedagang menjual minyak goreng pada 23 November 2021 dg 3 merek
yg berbeda seharga 14.000 per liter. Harga minyak Bamoli naik 40 % dari harga
semula. harga minyak sunmo 5% lbh murah dari Bamoli, selisih harga minyak Fortune
dg Bamoli 2 x selisih sunmo & Bamoli.
Ditanya: harga masing² minyak goreng saat ini?

Figure 2. Subject's answer sheet (with high learning motivation) during the process of understanding the problem

Based on the illustration in Figure 2, the subject can write down various data or information relevant to the problem, including both the known and the asked data. This indicates that in the process of understanding the problem, the subject does not face any difficulties. Confirmation of this was also obtained through an interview conducted by the researcher. In the interview, the subject stated that they often practice solving various mathematical problems with similar characteristics. Therefore, when confronted with the problem presented in Figure 1, the subject felt quite confident and did not encounter significant obstacles in the PS process.

Subjects with moderate learning motivation begin this process by identifying the problem. The subject is seen reading the problem several times during the identification process. The researcher confirmed this through an interview, where the subjects stated that to understand the problem, they read the problem sheet several times. Additionally, the subject was highlighted in certain parts of the problem. The subject mentioned in the interview that highlighting parts of the answer sheet was done to mark important parts of the problem information to facilitate understanding before writing down information or data on the answer sheet. The subject's answer sheet is displayed in Figure 3.

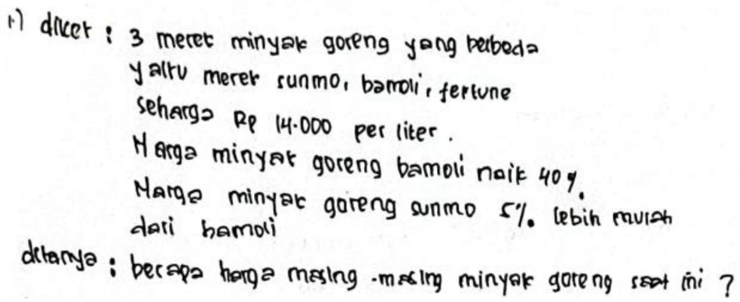
1) diket: 3 merek minyak goreng yang berbeda
yaitu merek sunmo, bamoli, fortune
seharga Rp 14.000 per liter.
Harga minyak goreng bamoli naik 40%.
Harga minyak goreng sunmo 5%. lebih murah
dari bamoli
ditanya: berapa harga masing-masing minyak goreng saat ini?

Figure 3. Subject's answer sheet (with moderate learning motivation) during the process of understanding the problem

From the illustration displayed in Figure 3, we can observe in detail and clearly how the subjects worked on and wrote their answers. The subject carefully and accurately recorded all the data and information in the given problem. Furthermore, the subject systematically organized and categorized this information. Starting from the initial data provided in the problem, namely the initial price of cooking oil, the subject also noted the price increase described in the problem. Then, the subject continued by calculating and recording the final price of the cooking oil after considering the previously mentioned price increase. All this information was neatly written, clearly showing the subject's thought process in solving the problem. This shows how the subject could understand, integrate, and apply the information provided in the problem completely and accurately.

Subjects with low learning motivation exhibited interesting behavior when given the task of understanding the problem. Despite being considered to have low motivation, the response shown by this subject had some similarities with the subject with moderate learning motivation. One similarity is how the subject responded to the problem sheet by making marks or highlights on certain parts. Through an interview, the subject stated that this method was an effort to mark or highlight information they considered important. However, there was a notable difference between the subject with low learning motivation and the previous subject, as the low-motivation subject needed to read the problem repeatedly to understand it, as the previous subject did. After highlighting parts of the problem sheet, they wrote it down on the answer sheet. This answer sheet is presented in Figure 4.

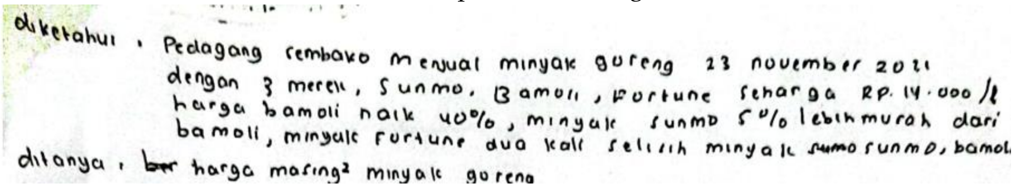
diketahui : Pedagang sembako menjual minyak goreng 23 november 2021
dengan 3 merek, Sunmo, Bamoli, Fortune seharga Rp. 14.000/l
harga bamoli naik 40%, minyak sunmo 5% lebih murah dari
bamoli, minyak fortune dua kali selisih minyak sumo sunmo, bamol.
ditanya : ber harga masing² minyak goreng

Figure 4. Subject's answer sheet (with low learning motivation) during the process of understanding the problem

In Figure 4, we can closely observe the subject's answers while understanding the problem. This subject, despite having low motivation, showed unique responses or characteristics compared to other subjects in this process. Nevertheless, the subject could still write the data or information completely and accurately.

3.2. Devising a Plan

PS is a crucial aspect in various scientific and professional fields. After identifying the problem and gathering related data, the next step is to design an effective and efficient PS strategy. Subjects with high motivation levels typically show greater initiative when facing challenges. In mathematical PS, this can be seen in how the subject processes the available information. After obtaining an initial understanding of the known data and the given questions, highly motivated subjects tend to take a more analytical approach. They attempt to rewrite the information in the form of mathematical language. The subject's answer sheet is shown in Figure 5, which heavily relies on the accuracy of the previously written data.

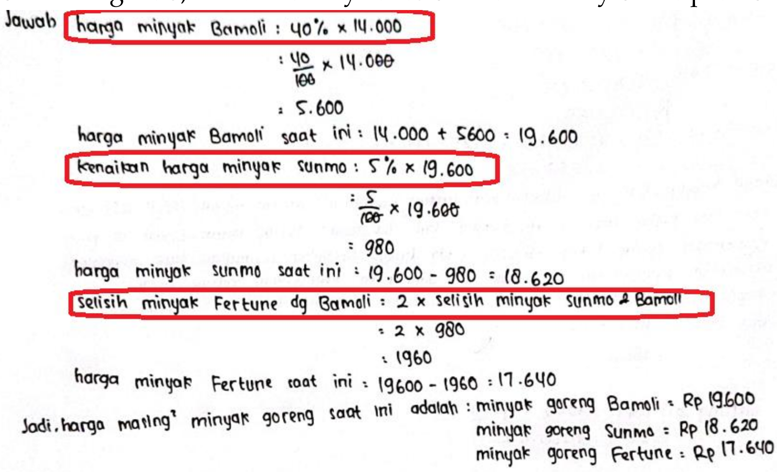
Jawab : harga minyak Bamoli : 40% × 14.000
: 40/100 × 14.000
: 5.600
harga minyak Bamoli saat ini : 14.000 + 5600 : 19.600
kenaikan harga minyak sunmo : 5% × 19.600
: 5/100 × 19.600
: 980
harga minyak sunmo saat ini : 19.600 - 980 : 18.620
Selisih minyak Fertune dg Bamoli : 2 × selisih minyak sunmo & Bamoli
: 2 × 980
: 1960
harga minyak Fertune saat ini : 19600 - 1960 : 17.640
Jadi, harga masing² minyak goreng saat ini adalah : minyak goreng Bamoli : Rp 19600
minyak goreng Sunmo : Rp 18.620
minyak goreng Fertune : Rp 17.640

Figure 5. Subject's answer sheet (with high learning motivation) during the process of designing a strategy

Before starting the task, each student was given an answer sheet and a scratch paper. The scratch paper was supposed to be used for calculations or designing the solution strategy before writing the answers on the answer sheet. However, this subject did not use scratch paper during this PS process. The researcher confirmed this through an interview, where the subjects stated that they were accustomed to solving such problems, so to save time, they wrote the solution strategy directly on the answer sheet.

In contrast, the subjects with moderate learning motivation demonstrated a more active and reflective behavior in their PS process. This is reflected in how they used scratch paper to design their PS strategy. In an interview, the subject mentioned that they felt they needed more confidence in solving the problem, and to be more thorough in their work, they used scratch paper to design the solution strategy. In this strategy design, the subject transformed the data, converting descriptive data into symbolic or mathematical language, as shown in Figure 6.

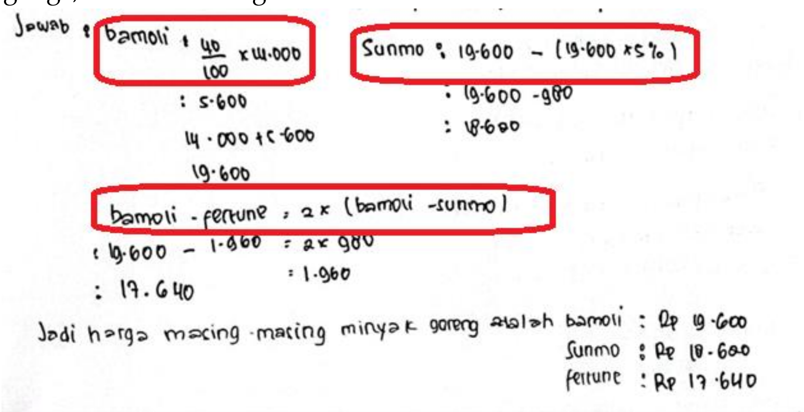

Figure 6. Subject's answer sheet (with moderate learning motivation) during the process of designing a strategy

In Figure 6, the subject wrote down the PS strategy (highlighted in red), determining the formula or equation to be used to calculate the price of each type of cooking oil. This formula is closely related to the previously written data; if the data is incorrect, the formula will also be incorrect. Similarly, an error in the strategy design phase will create a domino effect of errors in subsequent stages. Therefore, factors such as precision, accuracy, and conceptual understanding are crucial in every step of designing a PS strategy.

Subjects with low learning motivation exhibited similar responses to other subjects in the process of designing a PS strategy, which involved transforming data into mathematical language (Figure 7). Additionally, in this process, the subject also used their scratch paper to design the solution strategy before writing it down on the answer sheet.

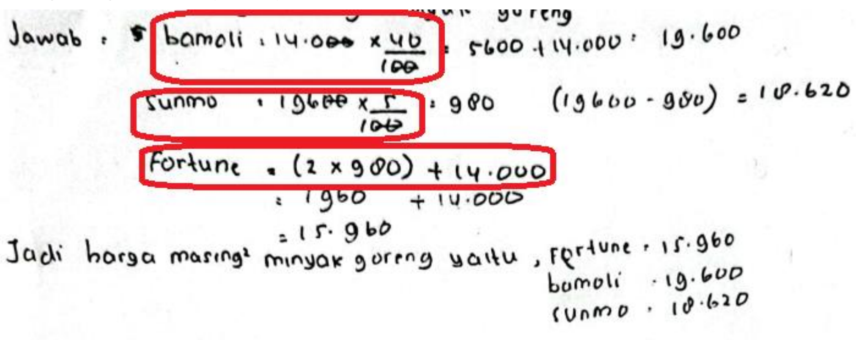

Figure 7. Subject's answer sheet (with low learning motivation) during the process of designing a strategy

In Figure 7, we observe an error in data transformation. In the final part, when calculating the price of the Fortune oil, the subject made a data transformation mistake. The researcher confirmed this through an interview, where the subjects stated that they still needed help to fully understand the problem's intent, compounded by their lack of mastery in algebraic concepts. This interview excerpt confirms that the process of designing a strategy requires a solid understanding of concepts and meticulousness in comprehending the problem.

3.3. Carrying out the Plan

The next step after designing a strategy is to apply the planned strategy. In this process, subjects with high learning motivation are seen performing computations based on the previously designed strategy, specifically the formula derived to solve the problem. This process heavily relies on the preceding step: if the obtained formula is incorrect, the calculations performed will be futile, and the resulting answer will be incorrect. Conversely, the answer will also be incorrect if the written formula is correct, but the calculations must be corrected. The observed response of this subject is that they did not use scratch paper for initial calculations, and they wrote directly on the answer sheet. The subject's answer sheet is shown in Figure 8.

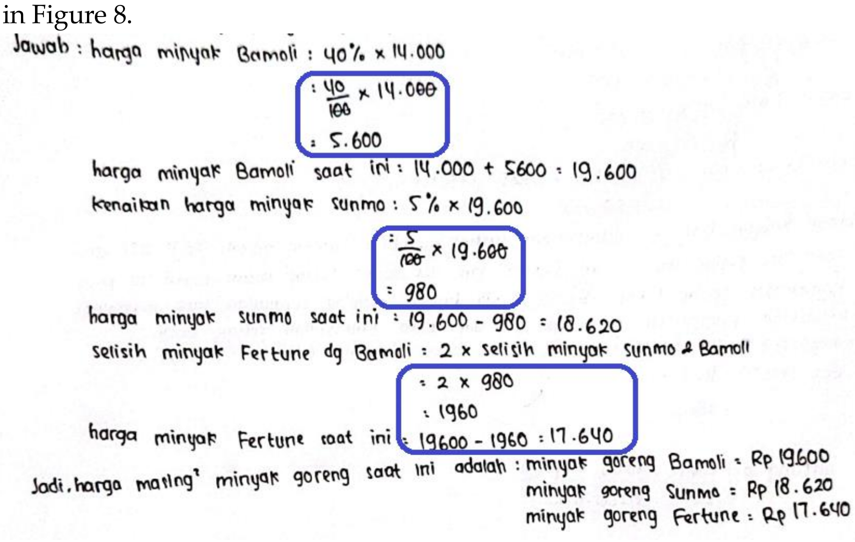

Figure 8. Subject's answer sheet (with high learning motivation) during the process of applying the strategy

Referring to Figure 8, the subject can perform calculations accurately, obtaining the correct answer. Even though they did not use scratch paper for calculations, this subject could compute correctly. This required confirmation from the researcher; the subject explained that the calculations were still simple enough to be written and calculated directly on the answer sheet. Moreover, their habit of solving such problems helped them solve them effectively.

The subject with moderate learning motivation begins this process by first calculating on the scratch paper before writing on the answer sheet. This subject consistently uses scratch paper whenever a calculation or computation is required. This shows an awareness of ensuring that each calculation step is done correctly and meticulously. This response differs from the previous subject, as this one uses scratch paper for computational calculations. During the interview, the subject mentioned that this method ensured accurate calculations. Additionally, they expressed concern that if calculations were done directly on the answer sheet and a mistake occurred, it would be difficult to correct without making the answer sheet look messy. The subject's answer sheet can be seen in Figure 9.

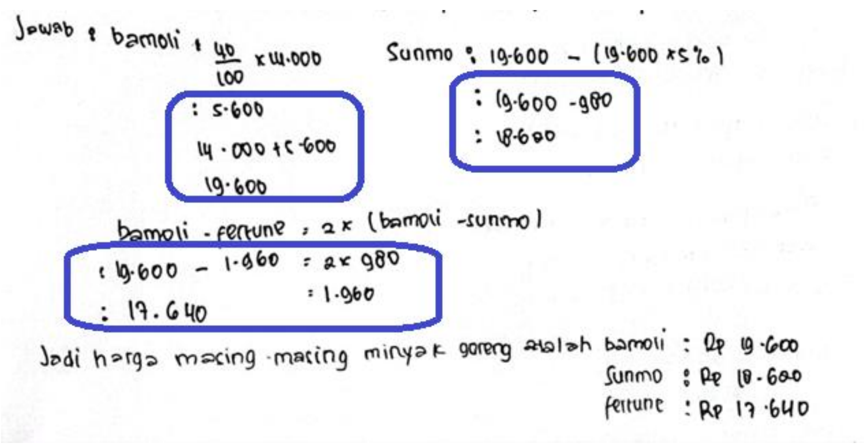

Figure 9. Subject's answer sheet (with moderate learning motivation) during the process of applying the strategy

In Figure 9, it can be observed that the subject performs calculations accurately, thereby obtaining the correct answer. This figure identifies the subject's calculation steps from the initial to the final stage. Initially, the subject begins by calculating each oil type's initial price. Then, considering the given percentage or amount of increase, the subject calculates the increase in the initial price. Consequently, the subject determines the new price of each oil after the increase. With the compiled data, the subject successfully constructs an argument and concludes the answer. This demonstrates the subject's analytical ability to understand data, apply mathematical concepts, and draw conclusions based on the performed calculations.

Subjects with low learning motivation respond similarly to those with moderate learning motivation during this process. Both categories of subjects, whether low or moderate motivation, share similarities in their approach to the learning process, especially in the calculation stages. Both prefer to process and check their calculations on scratch paper before providing the final answer or writing the response on the answer sheet. This step is crucial for them to ensure the accuracy and precision of the data to be transferred to the answer sheet. The subject's answer sheet can be seen in Figure 10.

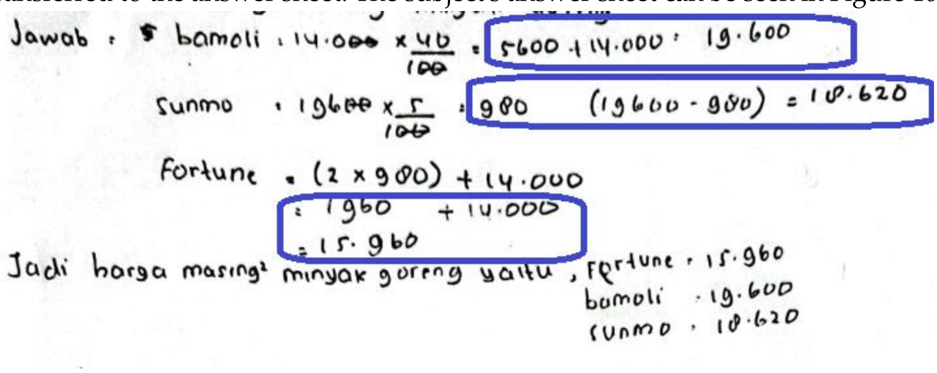

Figure 10. Subject's answer sheet (with low learning motivation) during the process of applying the strategy

Errors made in the previous stage lead to errors, resulting in an incorrect answer. This is confirmed by observing Figure 10, where the final answer obtained by this subject is wrong (last blue highlight). Although the calculations were error-free, the incorrect formula obtained led to a domino effect of errors in this application process. During the interview, the subjects stated that they performed the calculations accurately and needed to realize the answer was incorrect. From the interview excerpt, it is clear that the subjects felt they had done their best and were confident in their process. This highlights the importance of understanding basic concepts and selecting the correct calculation formula. Sometimes, even if the calculations seem perfect, a small error in the initial stage can lead to a significant mistake in the final stage.

3.4. Looking Back

The final step in the PS process is reviewing, which involves checking the steps taken to solve the problem. Subjects with high learning motivation are seen meticulously reviewing their answer sheets during this process. More importantly, these subjects check their work at each stage of the PS process. During interviews, the subjects mentioned that they always review what they have obtained, making this a habit when solving problems. This habit of checking and evaluating their work helps them understand any mistakes or shortcomings that may have occurred during the PS process, allowing them to correct these issues quickly. It is also observed that these subjects tend to complete their work relatively quickly compared to others, giving them more time to review their answers.

Subjects with moderate learning motivation also review their answers. However, this review differs from highly motivated ones who check the entire process or every PS stage. The moderate motivation subjects tend to check their answers only at the end, focusing mainly on the calculations. The researcher confirmed this condition through interviews, where the subjects mentioned that the time left after completing their work was very short, allowing them only to check their calculations. This interview excerpt indicates that the subjects were constrained by time, which was largely spent on the PS process, thus affecting the thoroughness of their answer review.

Subjects with low learning motivation admitted that they rarely solve mathematical problems, and observations showed that these subjects took the longest to complete the problems. This condition resulted in the subjects needing more time to review their answers. During the interview, the subjects explained that they needed more time while performing the calculations. Additionally, other factors, such as infrequent practice in PS, also played a significant role in their success in solving problems.

3.5. Summary of Problem-Solving Process Across Different Motivation Levels

Table 2. Summary of Problem-Solving Process Across Different Motivation Levels

Process Stage	High Motivation	Moderate Motivation	Low Motivation
Understanding the Problem	Quickly identifies and organizes key information. Confident with minimal difficulty.	Repeatedly reads and highlights key information. Systematic but cautious.	Takes longer, needs repeated reading. Marks key parts but with more effort.
Devising a Plan	Directly writes the solution strategy without scratch paper. Familiar with the process.	Uses scratch paper to carefully plan and convert data into mathematical language.	Uses scratch paper but makes errors in data transformation.
Carrying Out the Plan	Executes calculations directly on the answer sheet accurately.	Calculates on scratch paper first, then transfers correct answers to the answer sheet.	Makes correct calculations but is affected by earlier errors in the plan.
Looking Back	Reviews work at each stage, quickly identifies and corrects mistakes.	Primarily reviews calculations at the end due to time constraints.	Limited or no review due to time constraints and infrequent practice.

Discussion

Understanding the Problem

In problem-solving (PS), understanding the problem is crucial, and our study reveals varying characteristics among students based on their learning motivation. High-motivation students exhibit a consistent work ethic and frequent practice, which significantly enhances their ability to identify problems. This finding supports Chabibah et al. (2019) and extends existing literature by showing how motivation influences the initial stages of problem-solving. High-motivation students, who engage in regular practice, are more adept at understanding problem information, consistent with Argaw et al. (2017), Jonassen & H (2010), and Safitri (2018), who highlight the benefits of extensive study on PS skills.

Conversely, students with moderate motivation tend to read and re-read the problem information multiple times before recording it, indicating less consistent practice compared to high-motivation students. This aligns with Farahhadi & Wardono (2019), who note that PS requires significant effort. Moderate-motivation students, lacking the frequent practice habits of their high-motivation peers, need additional time and effort to grasp the problem. Low-motivation students also require repeated readings but often mark or highlight parts of the problem before writing them down. Although these students may appear less engaged, their marking indicates an underlying analytical ability, suggesting they have a basic understanding that remains underdeveloped due to limited practice (Rattan et al., 2012). This reflects that even students with low motivation have potential that can be harnessed through more practice.

According to Bandura's theory of self-efficacy (Bandura & Watts, 1996), high motivation is linked with greater self-confidence and persistence, leading students to approach problem-solving proactively and effectively. This is supported by research showing that high motivation correlates with quicker problem-solving due to increased confidence and practice (Suhendri, 2011; Abrami et al., 2011). High-motivation students benefit from reduced cognitive load and better focus, enhancing their problem-solving efficiency (Sweller, 1988).In contrast, students with moderate or low motivation often show limited cognitive engagement, resulting in less effective problem-solving strategies. To improve PS skills across different motivation levels, educators should implement strategies to enhance intrinsic motivation. This can be achieved by linking tasks to students' interests, providing relevant and meaningful problems, and promoting a growth mindset that values effort and learning over innate ability (Dweck, 2006).

Devising a Plan

In the step of devising a plan for problem-solving (PS), our study observed that the primary responses from subjects involved data transformation, converting descriptive information into symbolic mathematical language, and determining the formula needed. Students with high learning motivation did not use scratch paper during this phase. Their frequent practice with similar problems made formula determination more intuitive and automatic (Muhaimin & Kholid, 2023). This finding supports Patten's (2020) view that practice enhances problem-solving skills by making processes more intuitive. The efficiency in transforming data into symbolic language without external aids reflects a high level of automaticity, a concept supported by Alan & Lesley (2004), who assert that repeated practice leads to automaticity in problem-solving.

In contrast, students with moderate learning motivation relied on scratch paper to formulate their strategies. They needed additional time to think, compare, and sometimes engage in trial and error. Scratch paper helped them organize their thoughts and boost their confidence before finalizing their answers. This approach aligns with Farahhadi & Wardono's (2019) observation that external tools support problem-solving when internal strategies are less developed. Students with low learning motivation also used scratch paper, but their understanding of mathematical concepts often led to errors in determining the correct formulas (Atiqoh, 2019; Tambychik & Meerah, 2010). Schoenfeld (2014) emphasizes that a strong grasp of mathematical concepts is essential for effective problem-solving. Thus, teachers play a critical role in managing diverse student needs in the classroom. Overall, high motivation results in more frequent practice, leading to automaticity in problem-solving, while moderate and low motivation levels correspond with increased reliance on external aids and potential conceptual misunderstandings.

Carrying out the Plan

In the step of carrying out the plan in the problem-solving (PS) process, students demonstrate varying characteristics based on their motivation levels. High-motivation students typically perform calculations directly on the answer sheet without using scratch paper. Their ability to do so is rooted in their confidence and familiarity with problem-solving tasks, which allows them to work quickly and effectively (Surya & Putri, 2017). This behavior reflects high self-efficacy, as described by Bandura (1997), where strong belief in one's capabilities enhances both speed and accuracy in problem-solving. Research supports this, indicating that high-motivation students tend to solve problems faster due to their diligent practice and confidence (Suhendri, 2011; Abrami et al., 2011).

In contrast, students with moderate and low motivation tend to use scratch paper when performing calculations. They find it more comfortable and reassuring to have a tool to help them organize their thoughts and avoid errors (Muhaimin & Kholid, 2023). Using scratch paper can prevent mistakes and ensure more systematic and neat work, which is particularly important for problems involving detailed calculations (Raissi et al., 2019). However, this reliance on scratch paper does not always guarantee correct answers if the underlying strategy or formula is flawed. This issue was observed in low-motivation students, who made mistakes despite using scratch paper, highlighting the need for different instructional strategies to support these students (Jaenudin et al., 2017; Muhaimin et al., 2023, 2024).

This reliance on external tools is consistent with cognitive load theory, which suggests that such aids help manage cognitive load by offloading some mental work (Sweller, 1988). For students with moderate or low motivation, scratch paper helps to reduce errors and organize their calculations more systematically. High-motivation students, on the other hand, often exhibit a strong confidence in their problem-solving abilities, allowing them to focus on executing their plans more efficiently and accurately. This confidence not only contributes to quicker problem-solving but also helps in minimizing fundamental errors that could impede successful outcomes..

Looking Back

In the final step of the problem-solving (PS) process, which involves looking back, different characteristics emerge based on students' motivation levels. High-motivation students exhibit a more systematic approach to reviewing their work. They focus on evaluating each step and understanding the results, ensuring accuracy and minimizing errors (Lee, 2016). Their ability to solve problems quickly allows them to have more time to check their answers thoroughly, which further enhances the review process (Jonassen & H, 2010).

In contrast, students with moderate and low motivation often face challenges in the reviewing stage. These students tend to check their answers only at the end and may concentrate more on calculations rather than the overall process. Time constraints are a significant factor, as indicated by interview excerpts, with these students feeling that they have spent too much time on the PS tasks. This limitation highlights the need for educators to consider students' motivation levels when designing lessons, as understanding how motivation affects the PS process can help in creating more effective teaching strategies.

High motivation significantly enhances an individual's focus and persistence, leading to a more thorough understanding of the problem. According to cognitive theories, such as self-determination theory, intrinsic motivation—where students find personal meaning in the task—can improve persistence and problem-solving outcomes. Motivated individuals often experience positive emotions, which, as per the broaden-and-build theory, can enhance cognitive flexibility and creativity, allowing for innovative solutions.

On the other hand, students with moderate or low motivation may struggle to engage deeply with the problem. Their lack of intrinsic interest or external incentives can result in a superficial understanding and incomplete solutions. This reduced engagement and persistence can lead to frustration, which further impairs their problem-solving ability. This cycle of frustration and disengagement can prevent these students from fully developing their problem-solving skills..

4. CONCLUSION

This research examined how students with different levels of learning motivation approach problem-solving (PS) through stages like understanding the problem, planning a solution, executing the plan, and reviewing their work. Students with high motivation tend to quickly identify and write down problems and solve them directly on the answer sheet, while those with moderate or low motivation take more time to understand the problem and often use scratch paper for planning and calculations. Low-motivation students struggle more with selecting appropriate formulas and often make cascading errors throughout the process. High-motivation students frequently review their work, whereas those with lower motivation are less thorough, often skipping checks due to time constraints. The study identified factors like habits, confidence, and understanding of basic concepts as influential in students' problem-solving abilities. However, the study is limited by its focus on a specific student group, making the findings less generalizable, and it did not deeply explore factors affecting motivation. Future research could look into how teaching strategies, peer interactions, and classroom dynamics influence student motivation and problem-solving skills, as well as explore interventions to boost motivation across different learning environments. Educators can use these findings to create supportive classrooms that help build confidence and improve problem-solving skills, particularly for students with lower motivation.

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