ORIGINAL RESEARCH PAPER

Vocational high school students' mathematical problem-solving skills in PBL on composite functions

Dhiantika Aulia Hasna [1],* ⓘ**, Dwi Astuti** [1] ⓘ

[1] Department of Mathematics Education, Universitas Ahmad Dahlan, Yogyakarta, Indonesia
*Corresponding author

Abstract
Mathematical problem-solving skills remains a critical concern in Indonesian education. PISA 2022 results showing that Indonesian students' mathematical performance is significantly below the OECD average. This issue is particularly important in vocational high schools, where mathematics is closely related to technical and workplace applications. Although Problem Based Learning (PBL) has been widely reported as effective in improving students' problem-solving skills, most previous studies were conducted in general senior high schools and primarily focused on learning outcomes rather than examining students' problem-solving processes in depth. Research specifically analyzing vocational students' problem-solving characteristics at each stage of Polya's framework within PBL, particularly on composite functions, remains limited. This study aims to fill this gap by qualitatively analyzing Grade XI vocational students' mathematical problem-solving characteristics at each stage of Polya's framework within PBL instruction on composite functions. A qualitative descriptive approach was employed involving 34 students. Data were collected through validated essay tests, observations, and interviews. Data analysis was conducted using data reduction, data display, and conclusion drawing techniques. The findings indicate that most students were categorized at a moderate level (83.33%), demonstrating adequate procedural ability but weaknesses in the planning and reflection stages. The study highlights an imbalance between procedural and metacognitive development and suggests the need for explicit scaffolding in planning and reflection to strengthen vocational students' systematic problem-solving skills.

Keywords: composite function, PBL, problem-solving skills, students' worksheet, vocational high school

INTRODUCTION

Problem-solving skills are an important competency for students in the era of globalization and the 4.0 industrial revolution. Mathematics learning is not only about learning concepts or procedures, but also about thinking processes, reasoning, and applying concepts in context. (Darsono et al., 2021). Problem-solving skills can be seen from the extent to which students understand concepts, relate them, and apply appropriate solution strategies (Rambe & Afri, 2020). Mathematics learning has been given a larger portion of time in the curriculum due to its role in supporting the mastery of science, technology, and skills in the 21st century (Febriani et al., 2019). As a basic science, mathematics is expected to enable students to apply calculation concepts in their daily lives (Lestari & Juandi, 2023).

Problem-solving skills play a very important role for students at all levels of education (Pratidiana & Muhayatun, 2021). However, the results of the 2022 PISA survey show that Indonesian students' mathematical problem-solving skills are still relatively low. Indonesia's

mathematics score was only 366, down from 379 in PISA 2018, and far below the OECD average of 472. In fact, only 18% of Indonesian students were able to reach level 2 or higher in mathematical problem-solving (OECD, 2023). This condition shows the need to improve the quality of learning that can develop contextual mathematical problem-solving skills. This condition shows the need to improve the quality of learning that can develop contextual mathematical problem-solving skills. Good curriculum management is also needed to ensure that learning activities are effective and efficient, so that they can support the improvement of students' problem-solving skills (Gyanthi et al., 2023). In response to this situation, the government, through the Regulation of the Indonesian Ministry for Primary and Secondary Education Number 13 of 2025, emphasizes the importance of implementing deep learning at all levels of education, including vocational schools (Kementerian Pendidikan Dasar dan Menengah, 2025). This approach is aimed at strengthening students' critical thinking, creativity, collaboration, and problem-solving skills, so that the learning process becomes more meaningful and relevant to real-life situations.

According to Fadilah and Hakim (2022), mathematical problem solving is a process that involves systematic steps to obtain the correct solution. Polya (1978) emphasizes that mathematical problem solving consists of four main steps, namely understanding the problem, formulating a solution plan, implementing the plan, and reviewing the solution. The use of Polya's steps is expected to ensure that students not only know the results or answers, but also understand the process of finding the answers to the questions, because students are required to think critically and creatively (Al Kayyis et al., 2024).

At the vocational high school level, mathematical problem-solving skills are very important because they are directly related to the application of concepts in the students' fields of expertise. However, initial observations at the school show that 11th grade students still have difficulty understanding the material on composite functions, particularly in relating these concepts to problem-solving processes. These difficulties include the inability of students to understand problems in depth, such as identifying input and output variables in composition functions that are relevant to the students' fields of expertise, developing systematic solution plans, and applying the concept of composition functions to contextual problems in vocational fields, such as technical process flow analysis.

The above observations are in line with the research by Pratiwi and Hidayati (2022) which shows that vocational high school students' ability to solve mathematical problems based on Polya's procedure is still relatively low. Of the four stages of Polya, only about 33% of students were able to understand the problem correctly, 25% were able to formulate a plan appropriately, 55% successfully implemented the plan despite calculation errors, and 20% performed a recheck. The overall average achievement was only about 33%, indicating that students were not yet accustomed to following steps systematically. Further analysis reveals that even though students are able to solve problems procedurally, their understanding of the basic thinking process is still weak. This condition shows that mathematics learning still tends to focus on mastering formal steps and has not fully linked concepts to real-life contexts or vocational applications. This condition is in line with the view of Rahmadani et al. (2023), who state that mathematics is often considered difficult because its learning is formal and less relevant to everyday life. Therefore, a learning approach is needed that trains the application of Polya's stages in a holistic and contextual manner in the students' field of expertise. In line with these requirements, the questions used in this study were designed with reference to the vocational context of electrical engineering, such as calculating component costs and cable installation. The purpose of linking the questions to this vocational context was to ensure that the concept of composition functions was not understood in an abstract way, but was relevant to the students' field of expertise.

One effort to overcome this problem is to implement the Problem-Based Learning (PBL) model, which emphasizes real and contextual learning in accordance with the students' developmental stages and their daily experiences (Mukminin, 2022). Using the PBL model helps students learn to design a systematic problem-solving process so that knowledge is obtained from meaningful learning experiences (Marchy et al., 2022). The problem-based approach is carried out through student-centered learning activities that encourage active involvement, starting from problem identification to the acquisition of new knowledge and skills (Hasan & Nindiasari, 2023). According to Veronika et al. (2024), the main stages of Problem-Based Learning include orientation to the problem, organizing students for learning, guiding individual and group investigations, developing and presenting the results of students' work, and analyzing and evaluating the problem-solving process.

A number of studies show that PBL is effective in improving students' mathematical problem-solving skills because it requires active involvement in understanding problems, designing strategies, implementing solutions, and reviewing results in line with Polya's procedures. An analysis of the results of Putri and Erita (2024) study shows that high school students' mathematical problem-solving skills in composite function material are relatively good, with most students able to follow Polya's steps systematically. These findings emphasize the importance of improving the quality of mathematics learning so that students become more skilled at following structured problem-solving steps.

However, based on a review of several previous studies, studies on mathematical problem-solving skills through PBL on the subject of composite functions have been conducted more at the high school level. Research at the vocational high school level is still limited, especially those that qualitatively analyze students' problem-solving processes through the results of their work on PBL-based worksheets. Setyawan and Suparman (2023) stated that PBL-based worksheets can help students analyze problems contextually and develop solution plans according to their areas of expertise. Similarly, Santi et al., (2022) showed that PBL tools equipped with student worksheets were effective in facilitating the mathematical problem-solving abilities of vocational high school students. However, these studies generally focused on learning outcomes and did not specifically examine how vocational high school students demonstrated each stage of problem solving according to Polya's framework in the context of PBL learning on composite function material.

Thus, there is still a research gap in understanding the characteristics of vocational high school students' mathematical problem-solving abilities as specially at electrical engineering each stage of Polya through in-depth analysis of their work in PBL-based student worksheets. This study focuses on analyzing the mathematical problem-solving abilities of 11th grade vocational high school students through the application of the PBL model assisted by student worksheets on the subject of composite functions. Unlike previous studies, which generally focused on learning outcomes or were conducted at the high school level, this study specifically examined the problem-solving process of vocational high school students at each stage of Polya through an analysis of student work results on student worksheets in PBL learning.

Therefore, this study aims to qualitatively describe the mathematical problem-solving abilities of vocational high school students at each stage of Polya in the context of PBL learning assisted by student worksheets. The findings of this study are expected to provide a clearer understanding of the strengths and difficulties of students at each stage of problem solving, as well as to serve as a basis for the development of more contextual mathematics learning in vocational high schools.

RESEARCH METHOD

This study uses a qualitative approach with a descriptive research type, which aims to describe the mathematical problem-solving abilities of grade XI vocational school students through the

application of the Problem-Based Learning (PBL) model assisted by Student Worksheets on the subject of composite functions. The subjects of this study were 34 grade XI Electrical Engineering 2 students. The research procedure is described in detail in Figure 1.
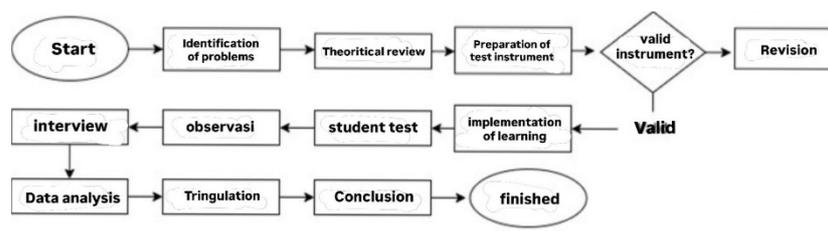

Figure 1. Research procedure

The research procedure began with the preparation stage, which included the development of learning tools such as PBL-based teaching modules, worksheets designed to include Polya's problem-solving stages, and research instruments in the form of descriptive tests, unstructured interview guidelines, and observations of student activities. The test instruments were developed based on Polya's mathematical problem-solving ability indicators and were validated by expert lecturers to ensure the suitability of the content and the measurability of the questions in relation to the research objectives.

In the research implementation stage, the activity began with the delivery of learning materials using the PBL model assisted by student worksheets on the topic of composite functions. During this process, students worked using designed based on Polya's problem-solving stages.

After the learning activities were completed, students were given an essay test consisting of two questions to measure their mathematical problem-solving abilities. Although the number of questions was limited, both questions were designed in the form of contextual problems that contained all of Polya's stage indicators. Each question required students to show the complete solution process, so that it not only assessed the final answer but also the students' strategic and reflective thinking abilities. The problems used in this study are presented in the Appendix section.

This study did not rely solely on the results of written tests. To obtain a more in-depth picture of the students' thinking processes, unstructured interviews were conducted with three students selected based on their test results, namely high, medium, and low categories. The interviews were conducted based on the students' answers on the test to further explore the strategies and considerations used in each stage of problem solving. In addition, observations of student activities during learning were also carried out as supporting data to see student involvement in problem-based learning processes.

Data analysis was conducted using the Miles dan Huberman (1994) model, which consists of three stages: data reduction, data presentation, and conclusion drawing and verification. In the data reduction stage, test results were analyzed by identifying the suitability of students' answers to each indicator of Polya's stages and then categorized based on ability level. Interview data were analyzed by examining students' answers to identify strategies, conceptual errors, and forms of reflection at each stage of problem solving. Findings from the interviews were then compared with the written test results and observation data during learning to see the consistency of students' thinking processes.

Conclusions were drawn iteratively by continuously comparing the three data sources until stable and consistent findings were obtained. To ensure data validity, triangulation techniques were used by comparing test results, interviews, and observations to ensure consistency and validity of research interpretations.

RESULTS AND DISCUSSION

Results

Analysis of the mathematical problem-solving abilities of grade XI vocational high school students in learning composite functions using a test instrument consisting of two questions that have been validated by experts. Assessment was carried out by categorizing students' mathematical problem-solving abilities into three reference levels, namely high, medium, and low, which were determined from the final score for problem-solving abilities.

Table 1. Percentage of problem-solving skills criteria

Category	Grade Criteria	Number of Students	Percentage
High	X ≥ 69	4	11.11%
Medium	53 ≤ X < 68	28	83.33%
Low	X < 53	2	5.56%
Total		34	100%

These results show that most students fall into the moderate category, which means that they are able to understand problems and attempt to solve them but are not yet consistent in planning and explaining the steps to solve them completely. Only a small number of students are able to reach the high category with coherent thinking processes and clear arguments.

High-achieving students' mathematical problem-solving skills

Based on the students' answers to Problem 1, students in the high category demonstrated a good understanding of the problem. Students were able to write down the important information from the question, namely the capacitor cost function $f(x) = 30.000x$ and the service cost function $g(x) = x + 50.000$. In addition, students were also able to identify the main questions of the problem, namely determining the form of the composite function and calculating the total cost when three capacitors are replaced. This shows that students understand the context and are able to separate relevant information from the question.

This finding is reinforced by the interview results, in which students stated,

> *S1 : I read the question slowly first, then I determine which information is known and which is asked, so that I don't make a mistake when working on it.*

This statement shows that students not only understand the information procedurally, but also have an awareness of the strategy in starting the problem-solving process. As shown in Figure 2, students wrote down the information systematically before starting the calculations.
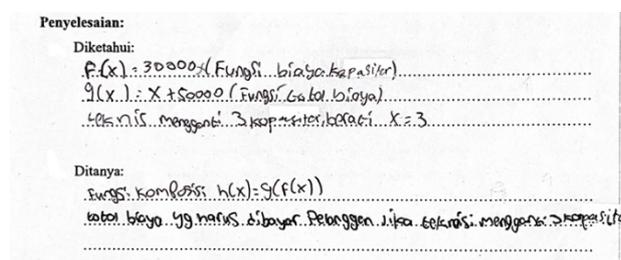

Figure 2. The stage of understanding problems by students in the high category.

When developing a solution plan, students can determine the appropriate mathematical model to use. Students wrote down both functions correctly and composed the composite function $h(x) = g(f(x))$. Then students develop the composite form into $h(x) = 30.000x +$

50.000. The solution plan was in accordance with the necessary steps, showing that students understood how to connect the concepts of component functions and service functions through the concept of composite functions.

This is in line with the student's interview response, which states, "Because there are two functions, I have to use a composite function. I first arrange the steps, starting with the first function and then moving on to the second function so that the result is correct." This quote shows that the student has the ability to consciously and systematically plan a solution strategy. Figure 3 shows a coherent and structured model.

Figure 3. The stage of developing a solution plan by students in the high category.

Next, in the implementation stage, students perform calculations according to the model they have created. Students calculate the value of $f(3) = 90.000$, then continue by calculating $g(f(3)) = 90.000 + 50.000 = 140.000$. The entire calculation procedure is carried out correctly and sequentially, demonstrating consistency and accuracy in applying the composition function in the context of the problem.

The interview results also show a strong procedural understanding, as expressed by the student,

> S1   :   *After getting the composition function, I calculate one by one in order. I checked again to make sure I didn't make a mistake.*

This statement confirms that the student's success was not only due to memorization of the procedure, but also due to an understanding of the solution process. As can be seen in Figure 4, the process was carried out without any conceptual or calculation errors.

Figure 4. The stage of implementing plan by students in the high category.

During the review stage, students also demonstrated their ability to draw accurate conclusions. Students wrote that the total cost to be paid by the customer was Rp140.000 when three capacitors were replaced, in accordance with the previous calculation results. Students also provided reflections that demonstrated their understanding of the use of functions and composite functions in solving repair cost problems.

This finding is reinforced by the students' statements in the interview,

S1   :   I looked at the final result again, then I compared it with the previous steps. If it matched, then I wrote down the conclusion.

This reflects a deep understanding when assessing the correctness of the solution found. This deep-thinking process can be seen in Figure 5.
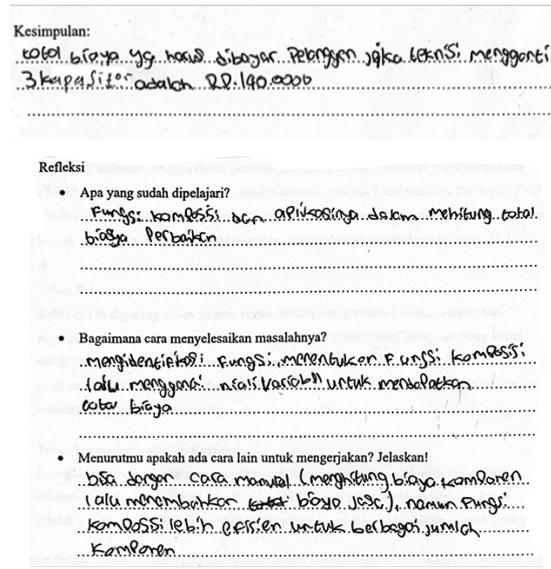

Figure 5. The review stage by students in the high category.

Overall, the results of this student's work show that students with high mathematical problem-solving abilities are able to carry out Polya's steps well. Students understand the problem, develop an appropriate plan, perform calculations correctly, and provide conclusions that are appropriate based on the context and calculation results.

Moderate-achieving students' mathematical problem-solving skills
Based on the students' work on question number 2, students in the intermediate category demonstrated a fairly good understanding of the problem. Students were able to identify the main information in the context of the question, namely two functions that describe the cable cutting process $f(x) = 0,9x - 3$ and the packaging function $g(x) = 0,95x$. In addition, students also grasped the core question, which was to determine the composite function and calculate the length of cable ready for delivery from the initial 500 metre cable. Although the presentation of information was not entirely organized, students still showed that they understood the meaning of the question and the important data required.

This is reinforced by the interview results, when the student stated,

S2   :   I actually understand the meaning of the question, know the functions used and what is being asked, but when writing on the student worksheets, I only wrote the important things, not everything.

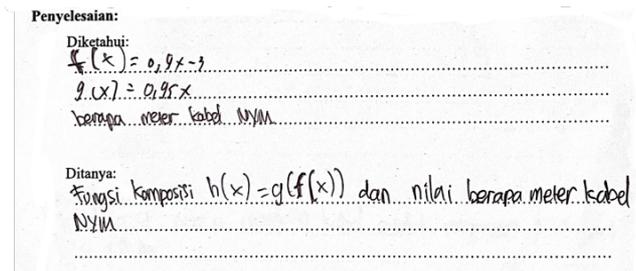As shown in Figure 6, the students wrote down the functions they already knew, but did not organize them neatly.

Figure 6. The stage of understanding the problems by students in the moderate category.

In the stage of developing a solution plan, students can choose the correct mathematical steps. Two functions are rewritten and students develop the composition relationship $h(x) = g(f(x))$. The composition function is developed correctly, although there are still some scribbles and the writing structure appears to be less systematic. However, conceptually, students have a suitable solution plan, which is to connect the cutting results to the packaging stage.

The students' statements during the interview also showed the appropriateness of this plan,

S2 : I know it has to be composed, but when writing the steps, I'm still confused about where to start, so the writing is a bit messy.

This shows that the students are aware of the interrelationship between the various processes, where the results of cutting serve as input in the packaging stage. This process can be seen in Figure 7.
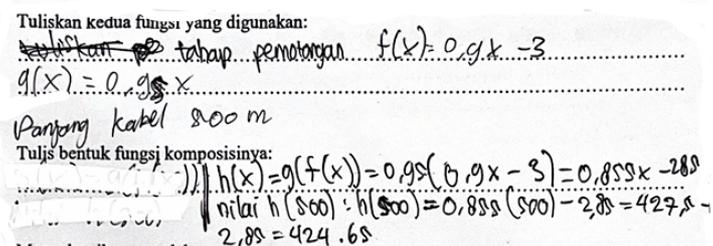

Figure 7. The stage of developing a solution plan by students in the moderate category.

Next, in the implementation stage, students demonstrated good calculation skills. The calculation of the value $f(500)$ was done correctly, yielding a result of 447. The student then continued by calculating the composite value by substituting it into the function g, and obtained $g(447) = 424.65$. As shown in Figure 8, the calculation procedure was carried out sequentially and produced the correct answer.
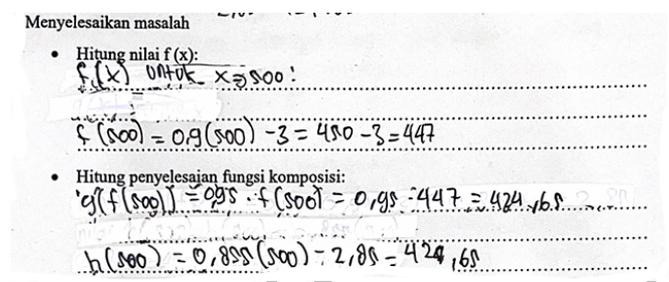

Figure 8. The stage of implementing plan by students in the moderate category.

However, based on interviews with students who stated,

> S2 : *I can calculate the result and get the answer, but sometimes I am still unsure whether my steps are consistent or not.*

During the review stage, students wrote down their conclusions about the final calculation results, namely that the length of the cable ready for shipment was 424.65 meters. Students also provided reflections, although these were still very brief and did not discuss the process of checking in depth. The reflections showed a basic understanding of the use of functions in modelling the cutting and packaging process, but did not fully demonstrate an evaluation of the steps taken.

This can be seen in Figure 9 and the student's statement during the interview,

> S2 : *I wrote down the conclusion from the calculation, but I didn't really check it again from the beginning. The important thing is that I got the answer.*

Figure 9. The review stage by students in the moderate category.

Overall, the results of the students' work show that their mathematical problem-solving skills are moderate. Students are quite good at understanding information and performing calculations, but they still need to improve the neatness of their presentation, the systematic writing of their plans, and the depth of their reflection at the review stage. By improving these aspects, students can improve the quality of their problem-solving in subsequent stages.

Low-achieving students' mathematical problem-solving skills
Based on the students' work on question number 1, it shows that students in the low category are able to identify the main information from the context of the question, namely the component cost function $f(x) = 30.000x$ and the service cost function $g(x) = x + 50.000$. However, students have not demonstrated adequate understanding at the problem comprehension stage. The information written by the students is limited; they do not include important information related to the question, such as the composition function. As shown in Figure 10, the information written is still limited and does not reflect a complete understanding of the problem.
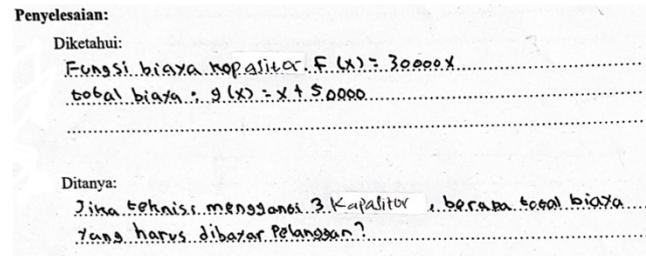
Figure 10. The stage of understanding the problems by students in the low category.

This finding is reinforced by the interview results, when the student stated,

S3 : I see that the question is about cost functions, but I'm still confused about which part to look for first, so I just wrote down what I remembered from the question.

At the stage of developing a solution plan, students wrote down part of the function form, but the presentation was incomplete and there was an error in one of the functions. The solution plan was not systematically organized, and the composition function form, which should have been the focus of the question, was not correctly described. This condition indicates that the students' understanding of the relationship between the two functions is still weak, and they are not yet able to develop solution steps that are in line with the objective of the problem.

This can be seen in Figure 11 and the student's statement during the interview,

S3 : I don't really understand how to connect the two functions. I just wrote down what I could, but I'm not sure if it's correct or not.
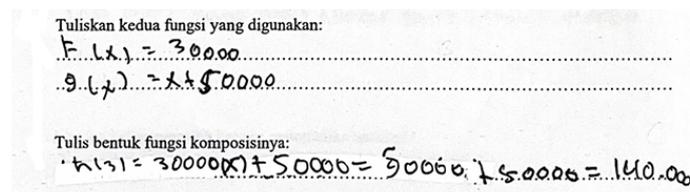

Figure 11. The stage of developing a solution plan by students in the low category.

Next, in the implementation stage, students attempted to perform calculations, but the steps they used did not follow the correct mathematical model. The calculations were performed without considering the composition function that should have been used, so the process and results were incorrect. This is shown in Figure 12. The steps taken by the students did not apply the concept of composition functions and operations in the given context.
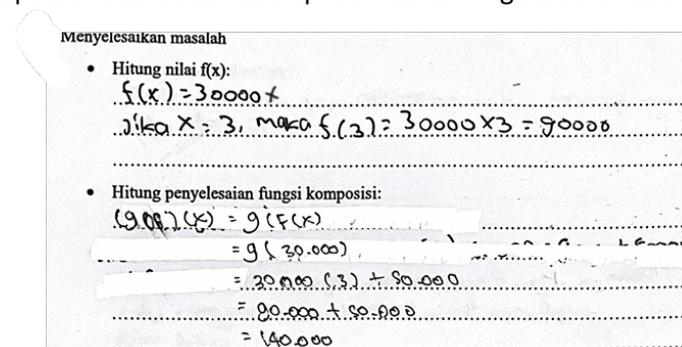

Figure 12. The stage of implementing plan by students in the low category.

The students' statements in the interviews reinforce these findings,

S3 : I just calculated it, but it turned out that the results were different. I'm also not sure how to use the composition function.

During the review stage, students only wrote down conclusions without linking them to the steps they had taken. In addition, the conclusions written were not supported by the correct calculation process, so they did not reflect any effort to review the answers or understand the mistakes that had been made. The reflections provided were also very general and did not demonstrate an understanding of the use of function concepts in solving the cost problem in Figure 13.

This is evident from the results of student interviews, which stated,

S3 : I just wrote down the final answer. I didn't have time to check again because I was still confused about the previous steps.

Figure 13. The review stage by students in the low category.

Overall, the results of the students' work show that students with low mathematical problem-solving abilities are not yet able to apply Polya's steps effectively. Students still experience difficulties in understanding the context of the problem, developing a plan, carrying out the calculation procedure, and drawing conclusions based on the correct results. These findings indicate the need for further guidance regarding the understanding of function concepts and how to use them to model situations in word problems.

Discussion

Based on the results of the study, most students were in the moderate category (83.33%), with a relatively small proportion in the high category (11.11%). These results indicate that the application of student worksheets assisted PBL has helped students understand the context of problems and perform calculations, but has not yet fully developed their systematic planning and reflection skills. These findings indicate that students' problem-solving abilities are still at the procedural level, namely being able to apply formulas and calculation steps, but have not yet fully developed in metacognitive aspects such as strategy planning and solution evaluation.

This condition is in line with the findings of Pratiwi and Hidayati (2022) which state that vocational school students tend to focus on the final solution rather than systematic thinking processes in accordance with Polya's stages. Furthermore, research conducted by Yustiana et al.

(2021) shows that vocational high school students are only able to reach certain stages of Polya's stages according to their characteristics, and the rechecking stage is the stage that is least often performed optimally. These results reinforce that the imbalance between procedural and reflective abilities is a phenomenon that is also found in the broader context of vocational education. However, this study expands on these findings by showing that even in learning that has been designed using a PBL approach assisted by student worksheets, development in the planning and reflection stages is still not optimal.

Understanding the problem
The results show that most students are able to identify known and asked information, especially through discussions and interviews. This indicates that the problem orientation stage in PBL plays an effective role in helping students understand the context of the problem verbally.

However, differences emerged when students were asked to write down their understanding in the worksheet. Many students in the moderate and low categories only wrote down the function form without explaining the meaning or relationship between variables. This condition shows a gap between conceptual understanding and written representation skills.

This finding is in line with Yustiana et al. (2021), who also found that students were able to write down what they knew but had not yet fully developed comprehensive explanations in the early stages of problem solving. Theoretically, this can be explained through the constructivist perspective, in which students' initial understanding is formed through social interaction and discussion but has not yet been fully internalized into a formally organized knowledge structure. This finding is in line with Rahmadani et al. (2023), who stated that students often understand problems intuitively but experience difficulties when they have to express them in coherent mathematical representations.

Developing a solution plan
The planning stage is the most challenging part for students in the middle and lower categories. Although they know that the solution requires a composition function, they are not yet able to systematically develop the steps in the form of a clear mathematical model.

This shows that students' problem-solving abilities, especially in designing strategies before performing calculations, are still limited. Many students tend to directly substitute values without explicitly formulating a composition model. A similar pattern was also found by Yustiana et al. (2021), where only some students were able to proceed from the problem understanding stage to the planning stage completely. This reinforces the findings of Fadilah and Hakim (2022), who stated that students often skip the planning stage and go straight to calculation. Thus, strengthening the planning stage needs special attention in problem-based learning.

Plan implementation stage
At the implementation stage, high and medium category students were relatively able to perform calculations correctly. This shows that conceptually, students understand the function composition procedure and are able to apply it in the context of the problem.

However, success at this stage was not accompanied by clear planning beforehand. This condition shows that students' procedural abilities are more developed than their strategic abilities. In the study by Yustiana et al. (2021), there were students who demonstrated the ability to implement plans without deep reflection in the final stage. This shows that students have mastered function composition but do not yet fully understand the structure of the relationship between functions in depth.

Review stage
The review stage is the stage that is least often carried out optimally, especially in the moderate and low categories. Most students only write down their final conclusions without evaluating the process they have gone through.

It indicates that students' reflective or metacognitive awareness is still low. In Polya's theory, this stage serves to ensure the consistency and validity of solutions. However, in practice, students are more oriented towards the final answer than the evaluation process.

Overall, analysis of each stage of Polya's theory shows that the application of PBL supported by student worksheets can help stimulate students to understand problems and perform calculations rather than developing plans and reflecting. These results indicate that PBL needs to be accompanied by guidance, especially at the planning and evaluation stages, so that students' mathematical problem-solving skills can develop in a more balanced and systematic manner.

CONCLUSION

This study aims to analyze the mathematical problem-solving abilities of vocational high school students on composite function material through the implementation of PBL assisted by Polya's stage-based student worksheets. Based on the findings, it can be concluded that the implementation of PBL assisted by student worksheets supports students in understanding contextual problems and carrying out solution procedures effectivelyHowever, the development of students' problem-solving abilities was not evenly distributed across each stage of Polya's stages. The stages of planning and reviewing solutions still require the most reinforcement. These findings indicate that students' procedural abilities are relatively more developed than their strategic and reflective thinking abilities.

Theoretically, this study confirms that the application of PBL does not automatically improve all aspects of problem-solving skills, especially in the metacognitive dimension. Therefore, the development of the ability to plan strategies and evaluate solutions needs to be designed more explicitly in the learning process. In practical terms, the results of this study imply that teachers should not only emphasize the accuracy of final answers, but also guide students in designing solution steps and reviewing the results obtained. student worksheets can be developed as a tool that contains guiding questions to train students to think more systematically and reflectively.

Therefore, the main contribution of this study lies in describing the problem-solving abilities of vocational school students based on Polya's stages in the context of PBL implementation supported by student worksheets. As a suggestion, further research could develop student worksheets that place greater emphasis on the stages of planning and reviewing answers. In addition, research could also be conducted on other mathematics materials or on different skill programs to see the development of problem-solving skills more broadly.

ACKNOWLEDGEMENT

DECLARATION

Author contribution
All authors contribute in the research and/or writing the paper, and approved the final manuscript.

Dhiantika Aulia Hasna — Conceptualizing the research idea, leading the investigation, setting up the methodology, analyzing the data, and writing the original draft.

Dwi Astuti — Assisting the investigation, reviewing the validity of the methodology, reviewing the data analysis, and revising the draft.

Conflict of interest
All authors declare that they have no competing interests.

Ethics declaration
We as authors acknowledge that this work has been written based on ethical research that conforms with the regulations of our institutions and that we have obtained the permission from the relevant institutes when collecting data. We support the International Journal on Education Insight (IJEI) in maintaining the high standards of personal conduct, practicing honesty in all our professional practices and endeavors.

The use of artificial intelligence
We do not use any generative AI tools to write any part of this paper.

Additional information
Not available.

REFERENCES

Al Kayyis, A., Tohir, M., & Muhasshanah, M. (2024). The urgency of Polya model problem-solving on students mathematical ability in facing the Industrial Revolution 5.0. *Alifmatika: Jurnal Pendidikan dan Pembelajaran Matematika, 6*(2), 218–231. https://doi.org/10.35316/alifmatika.2024.v6i2.218-231

Darsono, Hali, F., & Tahir. (2021). The effectiveness of the power of two method on mathematical problem solving ability of Class XI MA Attarbiah Islamiah Kolaka students. *Arus Jurnal Pendidikan, 1*(2), 1–9. https://doi.org/10.57250/ajup.v1i2.1

Fadilah, N. S., & Hakim, D. L. (2022). Analisis kemampuan pemecahan masalah matematis siswa SMA pada Materi Fungsi. *Jurnal THEOREMS (The Original Research of Mathematics), 7*(1), 64-73.

Febriani, P., Widada, W., & Herawaty, D. (2019). Pengaruh pembelajaran matematika realistik berbasis etnomatematika terhadap kemampuan pemahaman konsep matematika siswa SMA Kota Bengkulu. *Jurnal Pendidikan Matematika Raflesia, 4*(2), 120-135. https://doi.org/10.33369/jpmr.v4i2.9761

Gyanthi, N. M. W., Agustiana, I. G. A. T., & Firstia, D. G. (2023). Laps-Heuristic learning model improves mathematical problem-solving ability. *International Journal of Elementary Education, 7*(1), 169-177. https://doi.org/10.23887/ijee.v7i1.58407

Hasan, H., & Nindiasari, H. (2023). Efektivitas problem based learning (PBL) untuk meningkatkan kemampuan berpikir kritis siswa di SMK Negeri 2 Pandeglang. *NOTASI: Jurnal Pendidikan Matematika, 1*(2), 52-58. https://doi.org/10.70115/notasi.v1i2.99

Kementerian Pendidikan Dasar dan Menengah. (2025). *Ringkasan Peraturan Menteri Pendidikan Dasar dan Menengah Nomor 13 Tahun 2025 tentang Perubahan atas Peraturan Menteri Pendidikan Kebudayaan Riset dan Teknologi Nomor 12 Tahun 2024 tentang Kurikulum pada Pendidikan Anak Usia Dini, Jenjang Pendidikan Dasar, dan Jenjang Pendidikan Menengah*. Kementerian Pendidikan Dasar dan Menengah.

Lestari, I. D., & Juandi, D. (2023). Students' mathematical problem solving ability reviewed from adversity quotient: Systematic literature review. *Journal of Mathematics and Mathematics Education, 13*(1), 56-75. https://doi.org/10.20961/jmme.v13i1.73997

Marchy, F., Murni, A., Kartini, K., & Muhammad, I. (2022). The effectiveness of using problem-based learning (PBL) in mathematics problem-solving ability for junior high school students. *AlphaMath: Journal of Mathematics Education, 8*(2), 185-198. https://doi.org/10.30595/alphamath.v8i2.15047

Miles, M. B., Hubermann, A. M. (1994). *Qualitative Data Analysis: An Expanded Sourcebook*. Sage Publications.

Mukminin, D. S. (2021). Model problem-based learning untuk meningkatkan hasil belajar peserta didik SMK Muhammadiyah Semin. *Jurnal Pendidikan Vokasi Otomotif, 4*(1), 47-56.. https://doi.org/10.21831/jpvo.v4i1.45569

OECD. (2023). *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*. OECD Publishing.

Polya, G. (1978). How to solve it: A new aspect of mathematical method second edition. In *The Mathematical Gazette* (vol. 30, p. 181). https://www.jstor.org/stable/3609122?origin=crossref

Pratidiana, D., & Muhayatun, N. (2021). Analisis kelancaran prosedural matematis siswa dalam menyelesaikan soal program linear. *UNION: Jurnal Ilmiah Pendidikan Matematika, 9*(2), 189-201. http://doi.org/10.30738/union.v9i2.9369

Pratiwi, R., & Hidayati, N. (2022). Kemampuan pemecahan masalah matematis siswa kelas XI SMK berdasarkan tahapan polya. *Jurnal Educatio FKIP UNMA, 8*(1), 256-263. https://doi.org/10.31949/educatio.v8i1.1978

Putri, F. A., & Erita, S. (2024). Analisis kemampuan pemecahan masalah matematis siswa pada materi fungsi komposisi. *Konstanta: Jurnal Matematika dan Ilmu Pengetahuan Alam, 2*(1), 32-39. https://doi.org/10.59581/konstanta-widyakarya.v2i1.1897

Rahmadani, A., Wandini, R. R., Dewi, A., Zairima, E., & Putri, T. D. (2022). Upaya meningkatkan berpikir kritis dan mengefektifkan pendekatan kontekstual dalam pembelajaran matematika. *Edu Society: Jurnal Pendidikan, Ilmu Sosial dan Pengabdian Kepada Masyarakat, 2*(1), 427-433. https://doi.org/10.56832/edu.v2i1.167

Rambe, A. Y. F., & Afri, L. D. (2020). Analisis kemampuan pemecahan masalah matematis siswa dalam menyelesaikan soal materi baris dan deret. *AXIOM: Jurnal Pendidikan dan Matematika, 9*(2), 175-187. https://doi.org/10.30821/axiom.v9i2.8069

Santi, I., Hutapea, N. M., & Murni, A. (2022). Pengembangan perangkat pembelajaran matematika model Problem based learning (PBL) untuk memfasilitasi kemampuan pemecahan masalah matematis peserta didik kelas x jurusan otomotif SMK. *Jurnal Cendekia: Jurnal Pendidikan Matematika, 6*(2), 1584-1602. https://doi.org/10.31004/cendekia.v6i2.1178

Setyawan, N. D., & Suparman, S. (2023). Pengembangan e-LKPD berbasis PBL terintegrasi kemampuan pemecahan masalah matematika peserta didik. *Jurnal Pendidikan Matematika RAFA, 9*(1), 35-48.. https://doi.org/10.19109/jpmrafa.v9i1.13306

Veronika, T., Ninawati, N., Fransiska, L., Rabiatul, A., & Yusawinur, B. (2024). Menggali potensi problem based learning: Definisi, sintaks, dan contoh nyata. *SOSIAL: Jurnal Ilmiah Pendidikan dan Ilmu Pendidikan Sosial, 2*(2), 121-128. https://doi.org/10.62383/sosial.v2i2.153

Yustiana, Y., Kusmayadi, T. A., & Fitriana, L. (2021). Mathematical problem solving ability of vocational high school students based on adversity quotient. Journal of Physics: Conference Series, 1806(1), 012092. https://doi.org/10.1088/1742-6596/1806/1/012092

APPENDIX

PROBLEM-SOLVING TEST

1. Andi is a technician who was asked to repair three fans belonging to his customers. Each fan had a problem with its capacitor, so each fan needed to have one capacitor replaced. A total of three capacitors needed to be replaced. The repair cost is calculated in two stages:
   - The component replacement cost is calculated based on the number of capacitors replaced. The component cost function is expressed as:
$$f(x) = 30000x$$
   where x is the number of components replaced and $f(x)$ is in rupiah.
   - A fixed repair service fee of Rp 50,000 is added after the component cost is calculated. The total cost function is expressed as:
$$g(x) = x + 50000$$
   Determine the composite function $h(x) = g(f(x))$ which represents the total cost of repairing a fan based on the number of components replaced. If Andi repairs 3 fans and replaces 3 capacitors, what is the total cost that the customer must pay?

2. An electrical installation project in a 5-story building requires NYM $3 \times 2.5 \ mm^2$ cable. This cable has 3 PVC-coated copper cores and is suitable for permanent installation inside buildings, such as power outlet and light connections. Before being sent to the project site, NYM cable is processed in two stages:
   - Cable Cutting Stage
   NYM cable initially comes in large rolls. The cable is cut to a standard size for each floor. The cutting machine also leaves a small section of the cable end for connection purposes. The length of the cable after the cutting process is formulated as:
$$f(x) = 0{,}9x - 3$$
   Where x = initial cable length (meters), and $f(x)$ = cable length after cutting and setting aside the ends.
   - Packaging and Quality Testing Stage
   Some of the cut cables are used for resistance and insulation testing before packaging. The length of the cable after this stage is calculated as:
$$f(x) = 0{,}9x - 3$$
   Where x is the length of the cable after cutting, and $g(x)$ is the length of the cable ready to be sent to the project.
   Determine the composition function $h(x) = g(f(x))$ which expresses the length of NYM cable ready for delivery based on the initial cable length. Then, calculate how many meters of cable are ready for delivery if the initial cable length is 500 meters.