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Adzkia Rahmatina, Ardhi Prabowo

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Students' Mathematical Problem-Solving Skills in Statistics Using an E-LKPD-Assisted Problem-Based Learning Model

Adzkia Rahmatina[1*], Ardhi Prabowo[1]

[1]Mathematics Education Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang

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ABSTRACT

Mathematical problem-solving skills are one of the key competencies that need to be developed in mathematics education because they support students in understanding problems, formulating strategies, carrying out solutions, and evaluating results systematically. However, these skills remain a challenge for students, particularly in mathematics learning involving contextual problems. This study aimed to describe students' mathematical problem-solving skills in statistics using a Problem-Based Learning (PBL) model supported by Electronic Student Worksheets (E-LKPD) based on Polya's problem-solving stages. The study employed a qualitative descriptive case study involving 32 eighth-grade students from Class VIII E at SMP Negeri 12 Semarang who participated in PBL supported by E-LKPD. Based on the mathematical problem-solving test results, three students representing the high, moderate, and low categories were purposively selected as the research subjects. Data were collected through mathematical problem-solving tests and semi-structured interviews and analyzed using the interactive analysis model of Miles, Huberman, and Saldaña, including data reduction, data display, and conclusion drawing and verification. Data credibility was strengthened through method triangulation. The results showed that students in the high category completed all four stages of Polya's problem-solving process. Students in the moderate category completed the stages of understanding the problem, devising a plan, and carrying out the plan but had difficulties in the looking-back stage. Meanwhile, students in the low category were unable to complete all four stages. These findings indicate that students' mathematical problem-solving skills differed across the three categories after participating in PBL supported by E-LKPD. The looking-back stage was the most challenging for students and therefore requires greater attention during the mathematics learning process.

Corresponding Author:

Adzkia Rahmatina,
Mathematics Education Study Program,
Faculty of Mathematics and Natural Sciences,
Universitas Negeri Semarang,
Jalan Taman Siswa, Gunung Pati, Semarang, Central Java 50229, Indonesia,
✉ adzkiarahmatina@students.unnes.ac.id

Introduction

Mathematical problem-solving skills are one of the essential competencies that should be developed through mathematics education. These skills involve not only obtaining correct answers but also understanding problems, devising appropriate solution strategies, carrying out the selected strategies, and evaluating the obtained results. Mastery of these skills is essential because it fosters logical, critical, and systematic thinking needed to address challenges in both learning and everyday life in the twenty-first century. The importance of mathematical problem-solving skills is also reflected in the Programme for International Student Assessment (PISA), which assesses students' ability to formulate, employ, and interpret mathematical concepts in solving contextual problems (OECD, 2023). However, the 2022 PISA results showed that Indonesian students scored 366 in mathematics, lower than the OECD average of 472 (OECD, 2023). These findings indicate that Indonesian students' mathematical problem-solving skills still require greater attention in mathematics education. Consistent with this, the National Council of Teachers of Mathematics (NCTM) identifies problem solving as one of the five process standards, alongside communication, reasoning, connections, and mathematical representation (NCTM, 2000). Therefore, this study adopts Polya's problem-solving stages—understanding the problem, devising a plan, carrying out the plan, and looking back as the analytical framework because these stages systematically describe students' thinking processes during problem solving (Polya, 2014).

One area of mathematics that is closely related to problem-solving skills is statistics. Statistics requires students not only to perform data calculations but also to understand the information presented, determine appropriate solution strategies, interpret the results, and draw conclusions based on the given context. These skills are essential because statistics is widely applied in daily life, such as interpreting survey results, analyzing data, and making decisions based on available information. Therefore, statistics instruction should be designed to engage students in activities that promote analytical thinking and systematic problem solving, thereby supporting the development of their mathematical problem-solving skills.

Although statistics plays an important role in daily life, it remains one of the mathematical topics that students find difficult to understand. Previous studies have shown that students still experience difficulties in understanding word problems, grasping basic statistical concepts, and distinguishing among measures of central tendency, such as the mean, median, and mode (Fauziah et al., 2024). In addition, students also struggle to interpret measures of central tendency as representative values and using them as a basis for decision-making (Haeni & Jatisunda, 2026). These findings indicate that statistics instruction should not focus solely on computational skills but should also provide opportunities for students to understand problems, devise solution strategies, carry out solutions systematically, and evaluate the results in accordance with Polya's problem-solving stages.

Students' difficulties in understanding statistics contribute to their low mathematical problem-solving skills. Several studies have shown that students' mathematical problem-solving skills remain low. Students experience difficulties in understanding problems, determining appropriate solution strategies, and connecting mathematical concepts when solving non-routine problems (Anggrayni, 2025). In addition, most students are still unable to accurately identify the given and required information, organize solution steps systematically, or perform a final review of their solutions (Hasibuan et al., 2026). Difficulties are also evident in the stages of devising a plan and looking back, indicating that several stages of the mathematical problem-solving process have not yet been carried out optimally (Hidayah & Murti, 2025).

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Similar conditions were also observed at SMP Negeri 12 Semarang. Based on an interview conducted with an 8th-grade mathematics teacher on April 27, 2026, students still experienced difficulties in understanding the problems, identifying the given and required information, determining appropriate solution strategies, and reviewing or checking their answers. Most students tended to proceed directly to calculations without first planning how to solve the problems, which often resulted in errors in both the solution process and the final answers. When examined based on Polya's problem-solving stages, these difficulties were evident across almost all stages of the problem-solving process. These findings indicate that students' mathematical problem-solving skills still require improvement through learning that promotes systematic thinking.

One factor contributing to students' low mathematical problem-solving skills is the continued use of teacher-centered learning, which provides limited opportunities for students to think critically and solve problems actively (Handayani et al., 2026). In the classroom, students more often receive information and work on routine problems by following the teacher’s examples. As a result, they are not accustomed to analyzing problems, devising solution strategies, carrying out solutions systematically, and evaluating the results they obtain. Consequently, students often experience difficulties when solving contextual problems that require higher-order thinking skills. Therefore, a learning approach that actively engages students in constructing knowledge through inquiry, discussion, and problem solving is needed.

One learning model that has been shown to be effective in improving students' mathematical problem-solving skills is Problem-Based Learning (PBL). In this model, learning begins with the presentation of a contextual problem that encourages students to identify the problem, gather relevant information, devise solution strategies, carry out the selected strategies, and evaluate the results through both individual and collaborative activities. These characteristics consistent with Polya’s stages of problem-solving. Previous studies have shown that Problem-Based Learning effectively improves students' mathematical problem-solving skills (Wulan et al., 2025). In addition, this model enhances students' critical and analytical thinking skills (Siswanto & Rahayu, 2025). Furthermore, integrating digital learning media into Problem-Based Learning creates a more interactive learning environment and positively supports the development of students' mathematical problem-solving skills (Setiawati et al., 2024).

To optimize the implementation of Problem-Based Learning, learning media are needed to effectively guide students through each stage of the learning process. One such learning medium is the Electronic Student Worksheet (E-LKPD). E-LKPD is a digital learning resource designed to help students engage in each stage of learning in a systematic and interactive manner. Through E-LKPD, students can access learning materials, activity instructions, and problem-solving tasks within a single integrated platform. In addition, E-LKPD enables students to document their thinking processes at each stage of problem solving, thereby making the learning process more structured and focused.

In this study, E-LKPD-assisted Problem-Based Learning is a problem-based learning approach that uses Electronic Student Worksheets (E-LKPD) as a supporting learning medium to facilitate students' learning activities throughout the instructional process. E-LKPD was integrated into the stages of organizing students for learning, guiding individual and group investigations, developing and presenting students' work, and analyzing and evaluating the problem-solving process. Through E-LKPD, students received activity instructions, solved contextual problems, documented the results of group discussions, and reflected on each stage of problem solving based on Polya's problem-solving stages. Thus, in addition to serving as a digital learning resource, E-LKPD supported the implementation of Problem-Based Learning by making the learning process more structured and encouraging students' active participation.

The positive impact of Problem-Based Learning and digital learning media on mathematics learning has been demonstrated in various studies. Problem-Based Learning supported by GeoGebra has been shown to improve students' mathematical problem-solving skills (Silalahi & Marethi, 2026). In addition, differentiated project-based learning has also demonstrated positive effects on students' mathematical problem-solving skills (Afdillah et al., 2024). E-LKPD has likewise been shown to enhance students' learning activities, motivation, and mathematics learning outcomes. However, most previous studies have focused on evaluating the effectiveness of learning models or media using quantitative approaches, with greater emphasis on improvements in learning outcomes. Studies that comprehensively examine students' mathematical problem-solving skills based on Polya's four problem-solving stages following the implementation of E-LKPD-assisted Problem-Based Learning, particularly in statistics learning for eighth-grade junior high school students, remain limited. Therefore, this study offers a novel perspective by analyzing students' mathematical problem-solving skills based on Polya's four problem-solving stages through the triangulation of mathematical problem-solving test results and interview data after the implementation of E-LKPD-assisted Problem-Based Learning.

Based on the preceding discussion, this study aims to describe students' mathematical problem-solving skills based on Polya's four problem-solving stages in statistics through E-LKPD-assisted Problem-Based Learning. The findings of this study are expected to provide an overview of students' mathematical problem-solving skills at each stage of Polya's problem-solving process, thereby helping teachers identify students' difficulties and determine appropriate learning strategies. In addition, this study is expected to serve as a reference for future research on mathematical problem-solving skills, particularly studies investigating the implementation of E-LKPD-assisted Problem-Based Learning.

Method

Type of Research

This study employed a qualitative descriptive case study approach. This approach was chosen because the study aimed to describe in depth students' mathematical problem-solving skills based on Polya's problem-solving stages during E-LKPD-assisted Problem-Based Learning. A case study design was adopted because the research focused on an in-depth analysis of students' mathematical problem-solving skills within a real-world learning context, allowing a more comprehensive understanding of students' thinking processes at each stage of problem solving (Mtisi, 2022).

Population and Samples

The population of this study comprised all eighth-grade students at SMP Negeri 12 Semarang. The research sample consisted of 32 students from Class VIII E, who were selected using purposive sampling. This sampling technique was employed to ensure that the selected participants met the objectives of the study. In qualitative research, purposive sampling is widely used because it enables researchers to select participants who are most relevant to the research focus (Ahmad & Wilkins, 2025). Class VIII E was selected based on the recommendation of the eighth-grade mathematics teacher at SMP Negeri 12 Semarang, taking into account the class characteristics that matched the research needs.

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All students in Class VIII E participated in statistics learning through E-LKPD-assisted Problem-Based Learning and completed a mathematical problem-solving skills test. The test results were used as preliminary data to identify students' mathematical problem-solving skills and served as the basis for selecting the primary research subjects. Based on the test results, students were classified into high, moderate, and low categories. One student from each category was then selected based on having a score that was most representative of the category, being able to clearly communicate their thinking processes during the interview, and being willing to participate in all stages of the study. Consequently, three research subjects representing the high, moderate, and low categories were selected. These three subjects were subsequently interviewed in depth to obtain detailed information about their thinking processes at each stage of Polya's problem-solving process.

Instruments

This study employed two research instruments: a mathematical problem-solving skills test and a semi-structured interview guide. The test was designed to collect data on students' mathematical problem-solving skills based on Polya's four problem-solving stages. Meanwhile, the semi-structured interview guide was designed to explore students' thinking processes in greater depth while solving mathematical problems at each stage of Polya's problem-solving process. Prior to their use in the study, both instruments were validated for content validity by one Mathematics Education lecturer and one junior high school mathematics teacher. The mathematical problem-solving skills test was administered after students had participated in statistics learning through E-LKPD-assisted Problem-Based Learning in eighth-grade junior high school. The test blueprint is presented in Table 1.

Table 1. Mathematical Problem-Solving Skills Test Blueprint

Learning Objectives	Mathematical Problem-Solving Stages	Question Indicators	Test Items
Through E-LKPD-assisted Problem-Based Learning, students are able to determine and interpret the mean, median, and mode of a data set to solve contextual problems accurately.	1. Understanding the Problem 2. Devising a Plan 3. Carrying Out the Plan 4. Looking Back	Students are able to analyze contextual data to determine the mean and evaluate the results as a basis for making decisions about production targets.	Jenang is one of the traditional souvenirs from Kudus. At "Manis Rasa" Jenang Store, an employee recorded the number of jenang packages sold over five consecutive days: 20, 25, 30, 15, and 10 packages. The store owner wants to determine the average daily sales to set the production target for the next period. Answer the following questions. a. Based on the situation above, can you draw a sketch to represent the situation? b. What information is provided in the problem? c. How would you determine the average number of packages sold per day? d. If you are confident with your answer, check whether your solution process is correct. e. After obtaining the result, what conclusion can you draw?

Learning Objectives	Mathematical Problem-Solving Stages	Question Indicators	Test Items
		Students are able to analyze two data sets by determining the median and mode and evaluating the significance of these measures based on a comparison of sales conditions between the two time periods.	Bakso is one of the most popular foods in Indonesia. At a bakso stall, the numbers of bowls sold during the first five days were recorded as follows: 25, 30, 28, 30, and 35. During the next five days, the numbers of bowls sold were 27, 32, 30, 31, and 29. The stall owner needs this information to evaluate the sales performance. a. Based on the situation above, can you classify the sales data into the first-period and second-period groups? b. What information is provided in the problem? c. How would you determine the median and the mode of each data set? d. After determining the median and mode of both data sets, what conclusions can you draw about the sales performance during the two periods? Explain your reasoning.
Through E-LKPD-assisted Problem-Based Learning, students are able to determine and interpret measures of data dispersion (range, quartiles, and quartile deviation) to solve contextual problems accurately.		Students are able to analyze data by determining measures of dispersion, including the range, quartiles, and quartile deviation, and evaluating the distribution of the data in a contextual problem.	Bayu recorded the number of visitors to a tourist park in Bandung over 11 consecutive days as follows: 120, 150, 140, 180, 200, 160, 170, 190, 130, 150, and 180. The data will be used to analyze the distribution of the number of visitors so that Bayu can understand the variation in the park's daily visitor levels. a. Based on the data above, what information can you obtain? b. How would you arrange the data to make it easier to analyze? c. How would you determine the range, the first quartile (Q_1), the second quartile (Q_2), the third quartile (Q_3), and the quartile deviation of the data? d. After obtaining the results, what conclusions can you draw about the distribution of the number of visitors to the tourist park? Explain your reasoning. e. If you are confident with your answer, check whether your solution process is correct.

Interviews were conducted with the three research subjects selected based on the results of the mathematical problem-solving skills test to obtain in-depth information about students' thinking processes at each stage of Polya's problem-solving process. The interview guide is presented in

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Table 2.

Table 2. Interview Guide

Stages of Mathematical Problem Solving	Interview Questions
Understanding the Problem	1. Were you able to understand the problem? Please explain the meaning of the problem in your own words.
	2. What information is given in the problem?
	3. What is the problem asking you to find?
	4. Are you confident that you identified the given information and the question correctly? Why?
	5. What plan or strategy did you use to solve the problem?
Devising a Plan	6. Why did you choose that strategy?
	7. How did you carry out the calculations based on the strategy you chose?
Carrying Out the Plan	8. Did you experience any difficulties while solving the problem? Please explain.
	9. How did you check your answer?
	10. What conclusion did you draw from your solution?
Looking Back	11. Do you think your solution is complete and correct? If not, what is still missing?

Data Collection

The study began with observations at the school to identify the learning conditions and problems that served as the basis for the research. Next, the research population and sample were determined. Before the learning activities were conducted, the researcher developed two research instruments: a mathematical problem-solving skills test and a semi-structured interview guide. Both instruments were validated by experts to ensure their suitability for the research objectives before being used. After the instruments were declared valid, mathematics instruction on the topic of statistics was conducted using an E-LKPD-assisted Problem-Based Learning (PBL) model. In the next stage, all students in Class VIII E completed a mathematical problem-solving skills test designed based on Polya's four problem-solving stages: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. The test results were analyzed according to students' performance at each stage of Polya's problem-solving process. Subsequently, three research subjects representing high, moderate, and low levels of mathematical problem-solving skills were selected using purposive sampling. Semi-structured interviews were then conducted with the three selected research subjects to obtain in-depth information about students' thinking processes at each stage of mathematical problem solving (Ruslin et al., 2022). In addition, documentation in the form of students' written work and learning activities was collected as supporting data to strengthen the analysis. The overall research procedure is illustrated in Figure 1.

Figure 1. Research Procedure

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Data Analysis

Data were analyzed using a qualitative descriptive approach based on Miles and Huberman's interactive analysis model, which consists of three stages: data reduction, data display, and conclusion drawing and verification (Miles et al., 2020). The analysis focused on students' mathematical problem-solving skills based on Polya's four problem-solving stages: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. During the data reduction stage, the researcher selected and focused on the mathematical problem-solving skills test results and interview data relevant to the research objectives. The interview transcripts related to students' mathematical problem-solving skills were then coded. The code "P" was used to represent the researcher, while "S01," "S02," and "S03" were used to identify each research subject in the interview excerpts. The coded interview data were subsequently organized according to Polya's four problem-solving stages to facilitate the analysis. The reduced data were then presented in the form of descriptive narratives, tables, and interview excerpts to facilitate the identification of students' mathematical problem-solving skills at each stage of Polya's problem-solving process. Finally, conclusions were drawn and verified through methodological triangulation by comparing the results of the mathematical problem-solving skills test with the interview findings. Based on this verification process, a comprehensive description of students' mathematical problem-solving skills during E-LKPD-assisted Problem-Based Learning was obtained according to Polya's four problem-solving stages.

Research Findings

The study was conducted over two learning sessions on statistics in Class VIII E at SMP Negeri 12 Semarang using an E-LKPD-assisted Problem-Based Learning (PBL) model. The first session focused on measures of central tendency, while the second session focused on measures of dispersion. During the learning activities, students worked collaboratively using the E-LKPD to solve contextual problems. The activities in the E-LKPD were designed based on Polya's four problem-solving stages. After completing the learning activities, students completed a mathematical problem-solving skills test. The validation results of the mathematical problem-solving skills test indicated that the instrument was suitable for use after revisions based on the validators' recommendations. The validators suggested adding guiding questions to help students demonstrate each stage of Polya's problem-solving process. Accordingly, the researcher revised the instrument by adding guiding questions for the stages of understanding the problem, devising a plan, and reviewing the solution, while no revisions were made to the carrying out the plan stage because it had already been considered appropriate. These revisions were intended to better capture students' thinking processes at each stage of mathematical problem solving.

Students' mathematical problem-solving skills were analyzed based on Polya's four problem-solving stages: understanding the problem, devising a plan, carrying out the plan, and reviewing the solution. Based on the results of the mathematical problem-solving skills test, three students representing the predetermined categories of high, moderate, and low mathematical problem-solving skills were selected as the research subjects. The selected students were then coded as S01, S02, and S03, as presented in Table 3.

Table 3. Coding of Research Subjects

Research Subject Code	Category
S01	High
S02	Moderate
S03	Low

Next, the results of the analysis of each student's mathematical problem-solving skills are presented.

Mathematical Problem-Solving Skills of the High-Ability Student

The results of the mathematical problem-solving skills test and the semi-structured interview with the research subject categorized as having high mathematical problem-solving skills (S01) are presented in Figure 2 and Figure 3. Based on the test and interview findings, S01 successfully completed the understanding the problem stage by accurately identifying and restating the given information and the question in the problem. During the devising a plan stage, S01 selected an appropriate solution strategy using the mean formula and clearly explained the reason for choosing the strategy. At the carrying out the plan stage, S01 performed the calculations systematically according to the planned strategy and obtained the correct solution. During the reviewing the solution stage, S01 checked the calculation process and wrote a conclusion consistent with the obtained answer. Based on these findings, S01 successfully demonstrated all four of Polya's problem-solving stages. This indicates that S01 was able to solve the problem systematically, beginning with understanding the problem and ending with reviewing the correctness of the final solution.

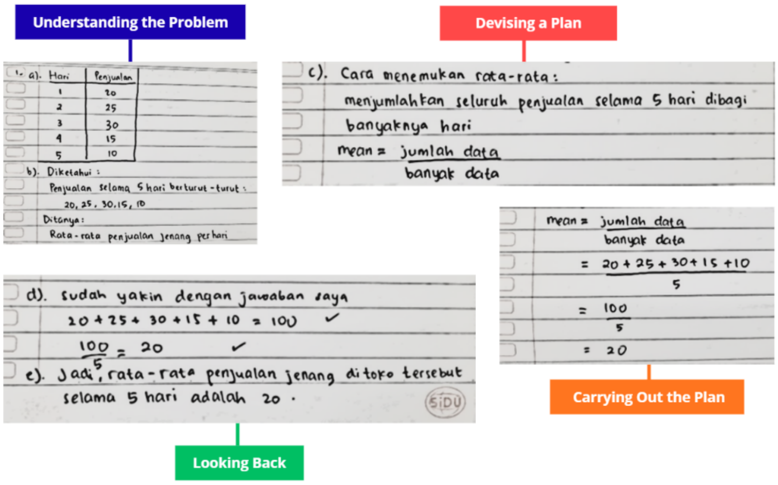

Figure 2. Mathematical Problem-Solving Skills Test Results of S01

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P : Please explain the meaning of the problem in your own words. **S01** : The problem asks me to find the average number of *jenang* packages sold over five days and determine the average daily sales. **P** : What information is given, and what is being asked in the problem? **S01** : The given information is the number of *jenang* packages sold over five days: 20, 25, 30, 15, and 10 packages. The problem asks for the average number of packages sold per day.	**Understanding the Problem**
P : What plan or strategy did you use to solve the problem? Why did you choose that strategy? **S01** : I added all the sales data together and then divided the total by the number of days using the mean formula because the problem asked for the average daily sales.	**Devising a Plan**
P : How did you carry out the calculations based on the strategy you chose? **S01** : First, I added all the daily sales: 20 + 25 + 30 + 15 + 10 = 100. Then I divided the total by 5 because there were five days, so the average was 20. **P** : Did you experience any difficulties while solving the problem? **S01** : No, I didn't because I already knew how to calculate the mean.	**Carrying Out the Plan**
P : How did you check your answer? **S01** : I recalculated the total number of packages sold, and the result was still 100. Then I divided it by 5 again, and the result was still 20. So, I was confident that my answer was correct. **P** : What conclusion did you draw from your solution? **S01** : In conclusion, the average number of *jenang* packages sold by the shop over the five-day period was 20 packages per day.	**Looking Back**

Figure 3. Interview Excerpt with S01

Mathematical Problem-Solving Skills of the Moderate-Ability Student

The results of the mathematical problem-solving skills test and the semi-structured interview with the research subject categorized as having moderate mathematical problem-solving skills (S02) are presented in Figure 4 and Figure 5. Based on the test and interview findings, S02 successfully completed the understanding the problem stage by accurately identifying and stating the given information and the question in the problem. During the devising a plan stage, S02 selected an appropriate solution strategy using the mean formula and explained the reason for choosing the strategy. At the carrying out the plan stage, S02 performed the calculations according to the planned strategy and obtained the correct solution. However, at the looking back stage, S02 did not recheck either the solution process or the final answer and did not write a conclusion based on the obtained result. Based on these findings, S02 demonstrated three of Polya's four problem-solving stages. S02 showed good mathematical problem-solving skills in understanding the problem, devising a plan, and carrying out the plan. However, S02 had not yet developed the habit of reviewing the solution by checking the correctness of the final answer and drawing an appropriate conclusion as a reflection on the solution obtained.

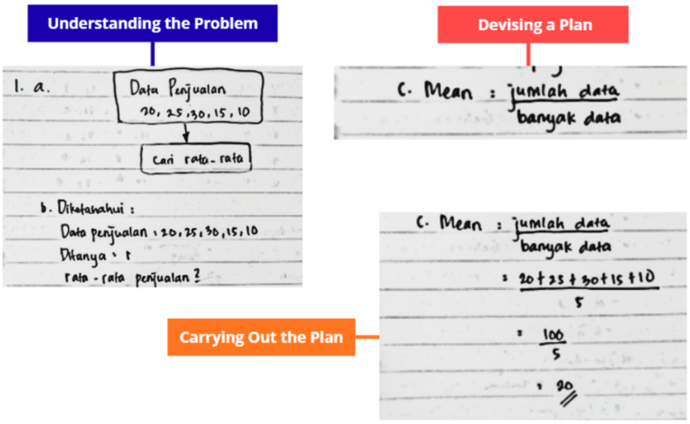

Figure 4. Mathematical Problem-Solving Skills Test Results of S02

P : Please explain the meaning of the problem in your own words. S02 : The problem asks me to find the average sales from the given data. P : What information is given, and what is being asked in the problem? S02 : The given sales data are 20, 25, 30, 15, and 10. The problem asks for the average sales.	**Understanding the Problem**
P : What plan or strategy did you use to solve the problem? Why? S02 : I used the mean formula, Ma'am. I added all the data first, then divided the total by the number of data because the problem asks for the average.	**Devising a Plan**
P : How did you carry out the calculations based on the strategy you chose? S02 : I added all the data first until the result was 100, then I divided it by 5 so the result was 20.	**Carrying Out the Plan**
P : How did you check your answer? S02 : I haven't checked yet, Ma'am. Once I got the result, I immediately stopped. P : What conclusion did you draw from your solution? S02 : I haven't written the conclusion yet, Ma'am.	**Looking Back**

Figure 5. Interview Excerpt with S02

Mathematical Problem-Solving Skills of the Low-Ability Student

The results of the mathematical problem-solving skills test and the semi-structured interview with the research subject categorized as having low mathematical problem-solving skills (S03) are presented in Figure 6 and Figure 7. Based on the test and interview findings, S03 was unable to successfully complete the understanding the problem stage because the student could not identify the given information and the question in the problem completely and accurately. During the devising a plan stage, S03 wrote down the mean formula; however, the interview findings revealed that S03 did not understand how to apply the formula and was therefore unable to continue the problem-solving process. At the carrying out the plan stage, S03 was unable to perform the calculations according to the selected strategy. Likewise, at the looking back stage, S03 did not review either the solution process or the final answer and did not write a conclusion because the problem was not solved successfully. Based on these findings, S03 did not demonstrate any of Polya's four problem-solving stages successfully. These findings indicate that S03 experienced difficulties from the initial stage of understanding the problem. As a result, the subsequent stages of devising a plan, carrying out the plan, and looking back could not be completed effectively.

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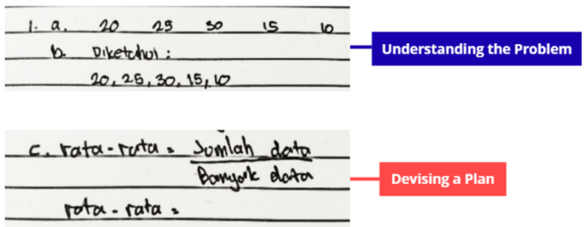

Figure 6. Mathematical Problem-Solving Skills Test Results of S03

P **S03**	: :	What information is given, and what is being asked in the problem? The given information is 20, 25, 30, 15, and 10, Ma'am. The question asks, but I'm not sure, Ma'am.	**Understanding the Problem**
P **S03**	: :	What does the problem ask you to find? Oh... the average of the sales, Ma'am.	
P **S03**	: :	What plan or strategy will you use to solve the problem? Why? I'm not sure, Ma'am. So, I looked at my friend's work first, then I wrote down the formula.	**Devising a Plan**
P **S03**	: :	How did you carry out the calculations based on the strategy you chose? I don't know, Ma'am. I'm confused about how to put the numbers into the formula.	**Carrying Out the Plan**
P **S03**	: :	How did you check your answer? I haven't been able to check it yet, Ma'am.	**Looking Back**
P **S03**	: :	What conclusion did you draw from your solution? I don't know the conclusion yet, Ma'am. I haven't got the answer.	

Figure 7. Excerpt from the Interview with S03

To ensure the trustworthiness of the data, methodological triangulation was conducted by comparing the results of the mathematical problem-solving skills test with the findings from the semi-structured interviews for each research subject. The results of the methodological triangulation are presented in Table 4.

Table 4. Methodological Triangulation Results for Each Research Subject

Research Subject	Method	Understanding the Problem	Devising a Plan	Carrying Out the Plan	Looking Back
S01	Test	✓	✓	✓	✓
	Interview	✓	✓	✓	✓
	Triangulation	✓	✓	✓	✓
S02	Test	✓	✓	✓	-
	Interview	✓	✓	✓	-
	Triangulation	✓	✓	✓	-
S03	Test	-	-	-	-
	Interview	-	-	-	-
	Triangulation	-	-	-	-

Based on Table 4, the results of the methodological triangulation indicate that the data obtained from the mathematical problem-solving skills test and the semi-structured interviews were consistent across all research subjects. S01 demonstrated consistent results between the test and interview by successfully completing all four of Polya's problem-solving stages. S02 also showed consistent findings by successfully completing the stages of understanding the problem, devising a plan, and carrying out the plan, but did not demonstrate the looking back stage. Meanwhile, both the test and interview findings for S03 indicated that the student was unable to demonstrate any of Polya's four problem-solving stages successfully. Therefore, the triangulation results strengthen the trustworthiness of the data, indicating that the findings regarding each student's mathematical problem-solving skills are consistent and credible.

These findings indicate that students' mathematical problem-solving skills were described based on the results of the mathematical problem-solving skills test and the semi-structured interviews conducted after students participated in E-LKPD-assisted Problem-Based Learning (PBL). During the learning process, the E-LKPD was used to support discussion and investigation activities that facilitated students in understanding the problem, devising a plan, carrying out the plan, and looking back, in accordance with Polya's problem-solving stages. The test and interview findings further showed that students demonstrated different levels of achievement across Polya's four problem-solving stages, corresponding to their categories of mathematical problem-solving skills.

Discussion

The findings of this study indicate differences in students' mathematical problem-solving skills across the three ability categories. These differences are reflected in students' achievement of Polya's four problem-solving stages. High-ability students successfully demonstrated all four stages, moderate-ability students demonstrated the first three stages, whereas low-ability students were unable to demonstrate any of the four stages successfully. These findings suggest that Polya's problem-solving stages are sequential and interrelated. Difficulties in the understanding the problem stage affected students' ability to devise a plan, carry out the plan, and perform the looking back stage. Therefore, success in the initial stage provides the foundation for successfully completing the subsequent stages of problem solving.

The ability to understand the problem demonstrated by the high- and moderate-ability students indicates that both students were able to accurately identify the given information and the question before determining an appropriate solution strategy. In contrast, the low-ability student was unable to identify the information completely, resulting in difficulties in determining appropriate solution steps. These findings support Polya's theory that understanding the problem is a crucial initial stage that determines the success of the entire problem-solving process (Polya, 2014). These findings are also consistent with previous studies showing that difficulties in understanding the problem lead to students' inability to determine appropriate solution strategies (Fitriyana & Sutirna, 2022).

During the devising a plan stage, the high- and moderate-ability students were able to determine appropriate solution strategies and explain the reasons for selecting them. In contrast, the low-ability student was unable to determine a solution strategy independently because the underlying mathematical concepts had not yet been fully understood. Consequently, the student experienced difficulties in connecting the information provided in the problem with the relevant mathematical concepts. This finding is consistent with previous research showing that students continue to experience difficulties, particularly during the devising a plan stage (Wahab et al., 2024).

Differences in students' mathematical problem-solving skills were also evident during the carrying out the plan stage. The high- and moderate-ability students were able to perform calculations according to the planned solution strategies and obtain the correct answers. In contrast, the low-ability student was unable to carry out the solution strategy accurately because the required solution steps had not yet been fully understood. These findings indicate that success at the carrying out the plan stage is influenced by students' ability to understand the problem and devise an appropriate solution strategy. During the learning process, E-LKPD-assisted Problem-Based Learning provided students with opportunities to discuss, explore information, and develop solution strategies gradually. The guiding questions in the E-LKPD

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helped students organize information, determine appropriate strategies, carry out the solution process, and perform the looking back stage, making their thinking processes more systematic. Therefore, the learning process emphasized not only the final answer but also students' thinking processes while solving mathematical problems. These findings are also consistent with previous research showing that Problem-Based Learning-based E-LKPD can improve students' mathematical problem-solving skills through interactive and student-centered learning (Rani et al., 2024). Furthermore, previous research has reported that Problem-Based Learning-based E-LKPD on statistics facilitates students in following the problem-solving process more systematically (Panjaitan et al., 2026).

During the looking back stage, only the high-ability student reviewed the calculation process and wrote a conclusion consistent with the obtained solution. The moderate-ability student neither reviewed the solution process nor wrote a conclusion, whereas the low-ability student did not reach this stage because the problem had not been solved successfully. These findings indicate that the looking back stage remains the most challenging stage for students. These findings are also consistent with previous research showing that students continue to experience difficulties in the looking back stage (Wahab et al., 2024). In addition, previous research has reported that most students are not accustomed to reflecting on either the problem-solving process or the obtained solution, even though this stage is essential for verifying the correctness of the answer and minimizing the possibility of errors (Hidayah & Murti, 2025).

Unlike previous studies, which generally focused on the effects of Problem-Based Learning (PBL) or the use of E-LKPD on improving students' mathematical problem-solving skills through quantitative approaches, this study provides an in-depth description of students' mathematical problem-solving skills at each of Polya's four problem-solving stages across the high-, moderate-, and low-ability categories through the triangulation of mathematical problem-solving skills test results and semi-structured interview findings after students participated in E-LKPD-assisted Problem-Based Learning. During the learning process, the activities in the E-LKPD were structured according to Polya's four problem-solving stages so that students were guided to understand the problem, devise a plan, carry out the plan, and perform the looking back stage before completing the mathematical problem-solving skills test. Therefore, the mathematical problem-solving skills test results and semi-structured interview findings were used to describe students' achievement at each of Polya's four problem-solving stages after participating in the learning process. The findings indicate that students' achievement at each of Polya's four problem-solving stages differed across the high-, moderate-, and low-ability categories. The looking back stage was the stage in which students experienced the greatest difficulty; therefore, greater attention should be given to this stage during instruction by providing regular practice and habituation so that students become accustomed to reflecting on both the problem-solving process and the obtained solution.

Conclusion

This study found that students' mathematical problem-solving skills in statistics differed across ability categories after participating in E-LKPD-assisted Problem-Based Learning (PBL). High-ability students successfully demonstrated all four of Polya's problem-solving stages: understanding the problem, devising a plan, carrying out the plan, and looking back. Moderate-ability students successfully demonstrated the first three stages but did not successfully demonstrate the looking back stage. In contrast, low-ability students were unable to demonstrate any of Polya's four problem-solving stages because they experienced difficulties beginning with the understanding the problem stage. These findings indicate that students' performance at the initial stage of problem solving influences their success in completing the subsequent stages. This study provides insight into students' mathematical problem-solving skills based on Polya's problem-solving stages after participating in E-LKPD-assisted Problem-Based Learning on statistics. The findings may serve as a reference for teachers in designing learning activities that emphasize students' thinking processes at each stage of problem solving, particularly by encouraging students to develop the habit of looking back. Future research is recommended to involve more diverse participants, different mathematics topics, and mixed-methods approaches to provide a more comprehensive understanding of students' mathematical problem-solving skills.

Conflict of Interest

The authors declare that there are no conflicts of interest.

Auhor Contributions

A.R. was responsible for the conceptualization of the study, data collection and analysis, visualization, drafting the initial manuscript, and revising the manuscript. A.P. was responsible for conceptualization, supervision, validation of the methodology, critical review of the manuscript, and approval of the final version for publication. The authors' contribution percentages are A.R.: 60% and A.P.: 40%.

Data Availability Statement

The authors state that the data supporting the results of this study will be provided by the corresponding author, [A.R.], upon reasonable request.

References

Afdillah, Izzati, N., & Febrian. (2024). Implementasi Pembelajaran Terdiferensiasi Menggunakan Model PjBL untuk Meningkatkan Kemampuan Pemecahan Masalah Matematis. *JKPM: Jurnal Kajian Pendidikan Matematika*, *2682*(2), 169–178. http://dx.doi.or/10.30998/jkpm.v9i2.22082

Ahmad, M., & Wilkins, S. (2025). Purposive sampling in qualitative research : a framework for the entire journey. *Quality & Quantity*, *59*(2), 1461–1479. https://doi.org/10.1007/s11135-024-02022-5

Anggrayni, U. Y. (2025). Pengaruh Model Problem Based Learning Berbantu LKPD Interaktif terhadap Kemampuan Pemecahan Masalah Matematis Siswa. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *09*(March), 395–408. https://doi.org/10.31004/cendekia.v9i1.3961

Fauziah, N., Muhtadi, D., & Herawati, L. (2024). Kesulitan Peserta Didik dalam Menyelesaikan Masalah pada Materi Pemusatan Data di SMP. *Jurnal Inovasi Pembelajaran Matematika: PowerMathEdu (PME)*, *03*(02), 163–176. https://doi.org/10.31980/pme.v3i2.1464

Fitriyana, D., & Sutirna. (2022). Analisis Kemampuan Pemecahan Masalah Matematis Siswa Kelas VII Pada Materi Himpunan. *Jurnal Educatio*, *8*(2), 512–520. https://doi.org/10.31949/educatio.v8i2.1990

Haeni, P. I. N., & Jatisunda, M. G. (2026). Indonesian Grade 11 Students ' Conceptual Difficulties with Measures of Central Tendency : An Nvivo-Assisted Qualitative Study of Representativeness , Visualization , and Decision Making. *Journal of Advanced*

Sciences and Mathematics Education, *6*(1), 218–237. https://doi.org/10.58524/jasme.v6i1.1072

Handayani, A. P., Paloloang, M. F. B., & Sugita, G. (2026). Meta-Analysis : The Influence Of Contextual Teaching And Learning Approaches On Mathematical Problem-Solving. *Prima: Jurnal Pendidikan Matematika*, *10*(1), 1–19. https://doi.org/10.31000/prima.v10i1.15172

Hasibuan, C. M., Simanungkalit, R. H., & Pangaribuan, F. (2026). Meningkatkan Kemampuan Pemecahan Masalah Matematis Siswa Pada Materi Persamaan Kuadrat Kelas IX. *Jurnal Imu Pendidikan Dan Sosial (JIPSI)*, *50*(4). https://doi.org/10.58540/jipsi.v4i4.1167

Hidayah, R. N., & Murti, R. C. (2025). Evaluating Mathematical Problem-Solving Skills in Primary School Students : Challenges and Insights from Polya ' s Framework. *Al-Ishlah: Jurnal Pendidikan*, *17*, 4984–4993. https://doi.org/10.35445/alishlah.v17i3.6534

Miles, M. B., Huberman, A. M., & Saldaña, J. (2020). *Qualitative data analysis: A methods sourcebook (4th ed.)*. SAGE Publicationsn.

Mtisi, S. (2022). The Qualitative Case Study Research Strategy as Applied on a Rural Enterprise Development Doctoral Research Project. *International Journal of Qualitative Methods*, *21*, 1–13. https://doi.org/10.1177/16094069221145849

NCTM. (2000). *Principles and Standards for School Mathematics*. National Council of Teachers of Mathematics.

OECD. (2023). *Kerangka Kerja Penilaian dan Analisis PISA 2022*. OECD Publishing. https://doi.org/10.1787/dfe0bf9c-en

Panjaitan, J., Mathematic, F. O., & Sains, N. (2026). Development Of E-LKPD Based on Problem Learning (PBL) to Improving Students' Mathematical Problem-Solving Ability On Statistics Material Class VIII Junior High School. *Jurnal Theorems (The Original Reasearch Of Mathematics)*, *11*(1), 73–89. https://doi.org/10.31949/th.v11i1.16263

Polya, G. (2014). *How to Solve It: A New Aspect of Mathematical Method*. Princeton University Pressko.

Rani, T. P., Sutiarso, S., & Firdaus, R. (2024). Integrating problem-based learning in e-lkpd : Enhancing problem-solving ability and adversity quotients. *Al-Jabar: Jurnal Pendidikan Matematika*, *15*(02), 505–519. https://doi.org/10.24042/ajpm.v15i2.23302

Ruslin, Mashuri, S., Rasak, M. S. A., Alhabsyi, F., & Syam, H. (2022). Semi-structured Interview : A Methodological Reflection on the Development of a Qualitative Research Instrument in Educational Studies. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, *12*(1), 22–29. https://doi.org/10.9790/7388-1201052229

Setiawati, A., Pertiwi, C. M., & Hidayat, W. (2024). Kemampuan Pemecahan Masalah Matematis, Model Problem Based Learning, Platform Book Creator: Muatan Pembelajaran Inovatif Abad 21 Bagi Siswa SMP. *Jurnal Pembelajaran Matematika Inovatif*, *7*(3), 555–566. https://doi.org/10.22460/jpmi.v7i3.23002

Silalahi, E. D. Y., & Marethi, I. (2026). Systematic Literature Review: Pemanfaatan Geogebra Dalam Model Problem Based Learning Terhadap Kemampuan Pemecahan Masalah Matematis Siswa. *Pendas : Jurnal Ilmiah Pendidikan Dasar*, *11*(2). https://doi.org/10.23969/jp.v11i02.49630

Siswanto, E., & Rahayu, W. (2025). *Optimalisasi Kemampuan Pemecahan Masalah Matematika melalui Implementasi Pembelajaran Problem Based Learning (PBL): Systematic Literature Review*. *09*(01), 181–195. https://doi.org/10.35706/sjme.v9i1.185

Wahab, A., Kusuma, Y. S., & Juandi, D. (2024). Jurnal Pendidikan Progresif Understanding Students ' Struggles in Solving Mathematical Problems : A Systematic Literature Review Using Polya ' s Framework. *Jurnal Pendidikan Progresif*, *14*(03). https://doi.org/10.23960/jpp.v14.i3.202411

Wulan, D., Rakhmawati, F., & Reflina. (2025). Pengaruh Model Pembelajaran Problem Based Learning Terhadap Kemampuan Pemecahan Masalah Matematika Siswa. *Relevan: Jurnal Pendidikan Matematika*, *5*(2). https://ejournal.yana.or.id/index.php/relevan

Authors Biography

	**Adzkia Rahmatina** is a student at Mathematics Education Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Central Java, Indonesia. ✉ adzkiarahmatina@students.unnes.ac.id
	**Ardhi Prabowo** is a lecturer in the Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Central Java, Indonesia. His research interests include mathematics education, mathematics teacher education, and Didactical Design Research (DDR). ✉ ardhiprabowo@mail.unnes.ac.id.