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ANALYSIS OF STUDENTS' COMPREHENSION IN SOLVING SOCIAL ARITHMETIC PROBLEMS BASED ON POLYA'S STEPS

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ABSTRACT

The ability to solve problems is a fundamental skill in mathematics education, yet many junior high school students struggle, particularly with social arithmetic problems. This issue is further complicated by the inconsistent application of structured problem-solving strategies like Polya's four-step method. This study aims to analyze students' comprehension in solving social arithmetic problems based on Polya's steps: understanding the problem, devising a plan, carrying out the plan, and looking back. A qualitative descriptive method was used, involving 30 randomly selected eighth-grade students from various junior high schools. Data was collected through problem-solving tests and student interviews, with evaluation based on Polya's indicators. The results reveal that only 17% of students demonstrated high problem-solving ability, while 60% fell into the low-ability category. Specifically, 70% could devise a plan, 50% understood the problem, 40% carried out the plan effectively, and only 23.3% reviewed their solutions. These findings indicate that students lack conceptual understanding and procedural fluency in solving real-life mathematical problems. The study implies that educators must emphasize structured problem-solving instruction and integrate strategies that enhance students' comprehension and metacognitive reflection.

KEYWORDS problem solving skills; Polya's steps; social arithmetic; student understanding

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INTRODUCTION

Mathematics is an important subject for students to master in the current era of technological development (Speed et al., 2020). Many other disciplines depend on mathematical developments and innovations, so mathematics is considered an important component of many different fields of science (Isnaintri et al., 2023) The purpose of learning mathematics in schools explains that the *hard skill* that students must master in learning mathematics is the ability to solve problems (Hermawan &

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Hutajalu, 2024) According to the *National Council of Teachers of Mathematics* (NCTM), problem-solving skills are one of the skills that must be mastered in learning mathematics in school, so that to improve logical, creative, mathematical, and critical thinking, students must be able to master the process and steps in solving mathematical problems (Aprilyani & Hakim, 2020). This is in line with Permendiknas No. 22 of 2006 which states the importance of problem-solving skills so that students can understand problems, be able to design mathematical models, be able to complete the design of mathematical models that have been prepared, and be able to interpret related to the solutions that have been obtained (Suhita Lestari et al., 2020). From these various statements, it can be understood that problem-solving skills are one of the important aspects of mathematics learning.

Problem solving is a process that is carried out in a planned manner to solve problems for which the answer cannot be known directly (Meutia, 2020). Russeffendi revealed that problem-solving skills are very important skills to master in learning mathematics, but not only for people who will study mathematics in the future, but also for those who will later apply it to other fields of science and in daily life (Nunung & Masri, 2020). Problem-solving skills are the ability to apply an understanding of concepts that have been learned to an unfamiliar situation. It can also be interpreted that problem-solving ability is the ability to combine various concepts learned to obtain a solution to a given problem. Students' mastery of this aspect of problem-solving skills is very important and will make mathematics learning more meaningful (Khoerunnisa & Puspita Sari, 2021).

The importance of mathematical problem-solving skills is not directly proportional to the facts in the field, because Indonesian students' problem-solving ability level is still relatively low. This can be seen based on the results of the PISA *(Program for International Student Assessment)* test, attended by 15-year-old students, a program initiated by the *Organization for Economic Co-operation and Development* (OECD) (Rosehana & Haerudin, 2023) The results of the Indonesian PISA test are still relatively low; this can be seen from Indonesia's PISA achievement in 2018, which was ranked 72nd out of 77 countries, with a mathematical ability score of 379 out of an average score of 489 (Annizar et al., 2020). The main figure in problem solving is George Polya (Isnaini et al., 2021). Therefore, this study will use Polya's steps to solve social arithmetic problems. According to Polya (1973), there are four indicators of problem solving, namely: (1) *understanding the problem*, (2) *devising a plan*, (3) solving the problem according to the plan (*carrying out the plan*), and (4) looking *back*.

Based on previous research, it was stated that not all students can and understand how to solve mathematical problems according to the right steps, this is because they do not understand the material or concepts that have been explained (Febriani & Najibufahmi, 2022). One of the materials in which there are problems in mathematics is social arithmetic. Social arithmetic consists of materials that discuss percentages, profits, losses, discounts, bank interest, taxes, and other materials relevant to daily economic activities. Generally, social arithmetic problems are presented as stories related to the economic field that are commonly applied or practiced daily. Facts in the field show that students' lack of

understanding of the concept of social arithmetic can be one of the causes of students' difficulties when solving social arithmetic problems.

Understanding is a person's ability to understand or understand something that has been acquired or learned, then what has been obtained or learned can be remembered and understood so that it can be reconveyed and developed according to the understanding they have (Sukaesih et al., 2020) Mathematics learning is inseparable from the understanding of the mathematical object itself, because in mathematics learning understanding is very important to realize learning goals. Students who have good problem-solving skills must have a good understanding of the problems given. Students' understanding of concepts in mathematics learning is very important, because with a good understanding of concepts, students can solve problems in mathematics learning (Radiusman, 2020). To find out how students' understanding of solving mathematical problems is needed.

Based on the above explanation, it can be seen that students' understanding of mathematics learning is significantly related to students' problem-solving skills. This is because when solving a problem, it is necessary to understand various concepts to obtain a solution. This research will be reviewed based on the Polya problem-solving steps, because using the Polya steps can help students solve mathematical problems in a structured, orderly manner and hopefully reduce the possibility of errors in the process of solving the given problems. This study aims to analyze students' understanding of concepts in solving social arithmetic problems based on Polya's steps. Through this study, it is hoped that the extent of students' understanding of solving social arithmetic problems based on Polya's steps will be known. In addition, it is also expected that the location of students' difficulties in solving social arithmetic problems can be known so that teachers or educators can determine suitable learning method solutions.

Although numerous studies have addressed students' problem-solving abilities in mathematics, few have specifically analyzed students' conceptual understanding of social arithmetic problems through the lens of Polya's four problem-solving steps. Most existing research focuses on general mathematical abilities or isolated problem-solving metrics, without assessing how well students internalize each step of Polya’s method. This study addresses that gap by evaluating students' comprehension at each stage—understanding the problem, devising a plan, executing the plan, and reviewing the solution—in the context of real-life arithmetic scenarios, providing a more structured and detailed analysis.

This study introduces a novel approach by combining qualitative and descriptive analysis to map junior high school students’ cognitive performance across all four of Polya’s problem-solving steps, specifically within social arithmetic topics. Linking individual step completion rates with conceptual misunderstandings uncovers performance levels and specific cognitive hurdles at each stage. This fine-grained diagnostic insight has seldom been addressed in previous research, making the findings particularly relevant for instructional refinement.

The primary objective of this research is to analyze the level of student comprehension in solving social arithmetic problems based on Polya’s problem-solving framework. The study seeks to identify which specific stages pose the most

difficulty for students and how these difficulties reflect their overall understanding of mathematical concepts in real-life problem contexts.

The results provide valuable insights for educators and curriculum developers by pinpointing where students struggle most within the problem-solving process. These findings can guide the development of targeted interventions, instructional strategies, and assessment tools that align with each stage of Polya's framework. Enhancing students' step-by-step comprehension will ultimately foster more effective learning, higher-order thinking, and improved performance in mathematics education.

RESEARCH METHOD

The method used in this study is descriptive with a qualitative approach. Descriptive research is a form of research conducted to describe existing phenomena, both natural phenomena and artificial phenomena (Rusandi & Muhammad Rusli, 2021). Qualitative research is research that analyzes descriptive data in the form of written words, and based on the words or speech of the person observed (Waruwu, 2023) This type of research is qualitative and descriptive because it aims to describe students' understanding of solving social arithmetic problems based on Polya's steps. This research will be conducted at the Junior High School (SMP) level. The target in this study is 30 students in grade VIII. In this study, a random sampling technique was used, with several students from several junior high schools taking part as samples.

The instruments used in this study were tests and interviews. This research began with the provision of a mathematical problem-solving ability test of social arithmetic material, with indicators based on Polya's problem-solving steps, namely: (1) *understanding the problem*, (2) *devising a plan*, (3) carrying *out the plan*, and (4) looking *back*.

This test determines the extent of students' understanding in solving mathematical problems by looking at the indicators that are met and those that are not. The rubric for the assessment of the problem-solving ability test based on the Polya steps (Nurmilah et al., 2023) is as follows: From the results of the test score on the problem-solving ability based on the Polya steps, it will then be converted into a percentage. The criteria used to determine the problem-solving ability based on Polya's steps were adopted from the assessment guidelines (Nurmilah et al., 2023): In this study, the qualitative data analysis techniques carried out were data collection, data reduction, data presentation, and conclusion drawn, in accordance with the opinions of Miles, Huberman, and Saldana (Zurianti & Hayati, 2024).

RESULT AND DISCUSSION

The maximum score is 15, with a score of 100. After processing the data from the social arithmetic problem-solving ability test on 30 junior high school students, the percentage of students' problem-solving ability level was obtained, as shown in Table 4 below.

Table 1. Percentage of Social Arithmetic Problem-Solving Ability Levels Based on Polya's Steps

No.	Value	Problem-Solving Ability Level	Many Students	Percentage
1.	$80{,}0 \leq nilai \leq 100$	Tall	5	17%
2.	$60{,}0 \leq nilai < 80{,}0$	Keep	7	23%
3.	$nilai < 60{,}0$	Low	18	60%

Table 1 above shows the results obtained by students in solving various social arithmetic problems, including 5 students with a high level of problem-solving ability, 7 students with a moderate level of problem-solving ability, and 18 students with a low level of problem-solving ability. Furthermore, from each category of levels, interviews were conducted with students who had conducted social arithmetic problem-solving skills.

Furthermore, from the 30 students who conducted the social arithmetic problem-solving ability test, 3 students were selected as representatives from each level of the problem-solving ability category. The data for each subject selected as a representative will be shown based on the results of the social arithmetic solving ability test. The following is the data of the results of the social arithmetic problem-solving ability test of 3 subjects that have been selected at each category level.

Table 2. Social Arithmetic Problem-Solving Test Results Based on Polya's Steps

No.	Subject	Score	Value	Category
1.	NJ	15	100	Tall
2.	BA	11	73,33	Keep
3.	DA	8	53,33	Low

Based on the results of the social arithmetic problem-solving ability test that students did, there are various ways to solve problems based on the questions given. From the various results obtained, some students do it correctly and in accordance with the Polya problem-solving steps, besides that some students do it correctly but are not in accordance with the Polya problem-solving steps, and some students have not been able to solve the social arithmetic problems given. Based on Table 2, 3 students were selected to represent each level of problem-solving ability, and interviews were conducted related to students' understanding of solving social arithmetic problems based on the Polya steps. The following is a description of students' problem-solving skills in solving social arithmetic problems based on Polya's steps.

NJ subjects can write down indicators to help them understand the problem perfectly. NJ subjects can write down what they know and ask questions in complete accordance with the information in the questions. NJ subjects can also

plan the solution of the problem appropriately by calculating the selling price after the discount and then calculating the total income per day after the discount, which brings the NJ subject to the correct answer. Judging from Figure 1, NJ subjects can carry out the settlement plan correctly and adequately according to the request, so that NJ subjects can find answers to the problems given. This proves that the NJ subject has met the 3rd indicator, namely the stage of carrying out the plan. From Figure 1, it can also be seen that the NJ subject has concluded based on the question request, based on the results obtained by the NJ subject at the stage of implementing the completion plan.

From the interviews conducted with NJ subjects, he reads the questions well first and then understands the problems in the questions, so that what is known and what is asked in the questions is obtained. Next, the NJ subject thinks about the steps to solve the given problem. NJ subjects can understand and write down what concepts or formulas are used in the implementation stage of the settlement plan that has been prepared, and get the correct answers according to the request. Furthermore, based on the interviews conducted, the NJ subjects re-examine the process that has been carried out by repeating the completion steps that have been done previously and then making conclusions according to the question request based on the answers obtained.

Based on the results of the analysis of the answers to the NJ subject, it was found that the NJ subject understood the problems in the problem well, so that he was able to plan the solution that would be carried out and then be able to carry out the solution plan that had been designed. Furthermore, NJ subjects also examined and made conclusions based on the answers that had been obtained. This means NJ subjects with high problem-solving abilities have met all four indicators of Polya's problem-solving steps.

BA subjects can write down the first indicator by writing down what is known and asked based on the given problem, but BA subjects have not been able to write down what is known from the questions in full. In Figure 2, the BA subject can already plan a good problem-solving approach, which directs the BA subject to the correct answer according to the request. BA subjects have also been able to carry out the problem-solving plan briefly and correctly, so that the results are obtained according to the request. Judging from Figure 2, the BA subject could not conclude the problems given based on the answers that had been obtained.

From the interview with the BA subject, he read the questions and then wrote down what he knew and asked. The BA subject can understand the problem, but he does not write down completely what is known about the problem because he is in a hurry to write the solution to the problem. Furthermore, the BA subject thinks about how to solve the given problem, then writes down the solution steps according to their plan, until the correct answer is obtained according to the question request. The BA subject has indeed understood the problem given, but the BA subject has not been able to re-examine and write the conclusion of the given problem. The BA subject revealed that it took him a long time to plan the settlement steps and execute the settlement plan that he had prepared.

Based on the results of the analysis of the answers to the BA subject, it is known that the BA subject can understand the problem, but has not written down

what is known in full, according to the information in the question. The BA subject is able to plan the solution steps and implement the solution plan correctly. However, BA subjects have been unable to apply the fourth step of solving Polya problems: re-examining and writing conclusions based on the answers obtained according to the question request.

DA subjects are able to write down what is known and asked in full according to the question request. This proves that the DA subject has met the first indicator, which is being able to understand the problem. Judging from picture 3, DA subjects are not perfect in planning the correct problem-solving according to the question request. This can be seen from the unknown, where the DA subjects obtained a score of 10,000. The DA subject has not been able to carry out the completion plan according to the request because the DA subject has not been able to plan the completion of the problem properly. From Figure 3, it can also be seen that the DA subject did not conclude the settlement he was working on.

From the results of interviews conducted on DA subjects, he could write down what he knew, ask according to the information in the question, and understand the problems. The DA subject has not been able to plan what settlement steps will be carried out systematically to obtain results according to the request. Although the DA subject was able to do half of the completion stage to the question request, the DA subject was not sure that his work was correct to the question request, because he was confused about how to solve the problem. As a result, the DA subject stopped taking the resolution step up to that stage and could not re-examine the Polya problem-solving step.

Based on the results of the analysis of the answers to the DA subjects, it is known that the DA subjects have been able to carry out the first indicator in the Polya problem-solving step. However, the DA subject has not been able to apply the second indicator perfectly, namely, planning the settlement that will be carried out correctly, and has not been able to carry out the settlement steps that he planned. The DA subject has also not been able to re-examine and write conclusions according to the request on the question given.

The results of the social arithmetic problem-solving ability test that the students have done show the following data on the students' problem-solving ability level based on Polya's problem-solving steps in each indicator of Polya's problem-solving steps.

Table 3. Social Arithmetic Problem-Solving Test Results Based on Polya's Steps in Each Indicator

Indicators	Percentage of Problem-Solving Ability
Understanding *the problem*	50%
Devising *a plan*	70%
Carrying *out the plan*	40%
Looking *back*	23,3%

Based on table 6 above, students who can solve problems based on Polya's steps in the first indicator, namely understanding *the problem,* are 50%, *devising a*

plan indicator is 70%, carrying *out the plan* indicator is 40%, and looking *back* indicator) is 23.3%. Based on interviews with several students, they knew the question request but were not used to writing down what they learned, and were asked, so most of them immediately planned the steps to solve the problem. The habit of students who rarely write down what they know and ask causes them to make mistakes when planning and solving the problems given. Even though the students have planned the completion steps, some are still unable to carry out the steps they planned. It is known that most students do not double-check the completion that has been done, so they do not know the most likely whether the completion made is correct or if there is an error at the stage of the work in their view.

In general, from the research that has been carried out, it is found that there are still many students with low problem-solving skills and many who have not been able to solve problems using the Polya problem-solving steps correctly. This is in line with previous research, which stated that the results of the research conducted showed that students' problem-solving skills were still relatively low (Fauziah et al., 2022) Of the 30 students who had taken the social arithmetic problem-solving ability test, only 17% could apply Polya's problem-solving steps correctly and adequately. Many students are not used to answering story questions that require problem-solving skills using Polya's steps. As revealed by Polya, problem-solving skills can be obtained from the ability to practice and *imitate* (Mawardi et al., 2022)

Based on the results of the interviews, some students admitted that they had not been able to understand the questions given. Of all students who have taken the test, it is known that 50% of them can understand the information and problems in the questions and write them well. Through the results of the interviews conducted, students who did not write down what they knew and what was asked in the question were because they did not understand the purpose of the question, forgot to write it, and some did not know how to solve the problem well. Most students who do not write down what information is known from the questions have difficulty planning the completion steps and completing the questions given.

In general, from the results of this study, it was obtained that students with a high level of problem-solving ability have a very good understanding of the problems and topics addressed in the given questions. Students with a high level of problem-solving ability can correctly apply the four steps of Polya's problem-solving in an orderly and correct manner. This is in line with research conducted by Herdiani Woro Dwi Satuti, which states that students with a high level of problem-solving skills can meet all four Polya problem-solving indicators (Satuti et al., 2023) Students with a high level of problem-solving ability can choose, apply, and write down formulas that are used to solve the given problems appropriately.

From the research results obtained on students with a moderate problem-solving ability, they can understand the problem given, but cannot write it down completely, because they are not used to solving problems using the Polya step. It should be noted that answering story questions with Polya's problem-solving steps can make it easier for students to solve the issues, and because the solution is done in an orderly and clear manner (Puspadewi, 2021) Then, students with a moderate problem-solving ability can correctly plan and execute problem-solving plans. However, students with a moderate problem-solving ability have not been able to re-examine the results of the answers obtained and make conclusions from the given problems.

Based on the research results, students with low problem-solving skills have a good understanding of the given problem and can write it, but they are not able to plan the problem perfectly and implement the solution plan. Students with low problem-solving skills cannot double-check the results and write down the conclusions from the answers obtained. Therefore, students with low problem-solving skills must practice solving story problems more like those in social arithmetic materials using Polya's problem-solving steps.

CONCLUSION

Students with a high problem-solving ability can solve social arithmetic problems using all four of Polya's steps, demonstrating complete comprehension and execution. Meanwhile, students with moderate problem-solving skills can understand the problem and execute the solution plan, yet often fail to articulate the problem fully and neglect the final step of re-evaluating and concluding their solution. Those with low problem-solving abilities tend to understand the problem but struggle significantly in planning and executing a solution and reviewing and summarizing their results. The findings reveal that most junior high school students still possess relatively low problem-solving proficiency when using Polya's method, indicating a pressing need to strengthen their conceptual understanding of social arithmetic. Enhancing students' skills in interpreting problems, selecting appropriate strategies, and reflecting on their solutions is critical for improving mathematical literacy. Therefore, future researchers are encouraged to investigate the effectiveness of intervention strategies, such as visual aids, digital tools, or differentiated instruction, on improving each stage of Polya's problem-solving framework. Longitudinal studies could also be conducted to track the development of problem-solving abilities over time and across varying levels of mathematical complexity.

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