Al-Jabar: Jurnal Pendidikan Matematika
Volume 14, Number 1, 2023, Pages 181 – 190
http://ejournal.radenintan.ac.id/index.php/al-jabar/index

Students talk about difficulties they have in solving math problems

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Article Information
Submitted May 23, 2023
Revised June 12, 2023
Accepted June 13, 2023

Keywords
Problem solving ability;
Responses.

Abstract

The ability of students' capabilities in solving mathematical problems extends beyond mere test questions, necessitating an analysis of students' responses to the problem-solving process. Hence, this study seeks to explore both the mathematical problem-solving skills of students and their reactions to the problem-solving procedure. The study adopts a descriptive-qualitative approach. Participants are drawn from three junior high schools (SMP) in Aceh, involving 76 students from class VIII as research subjects. The techniques employed for data collection encompass tests, observations, and interviews. Descriptive analysis is utilized to examine the quantitative data through proportions, while coding is applied for the analysis of qualitative data. The findings suggest that a quarter of the students noted down the known elements and posed queries, indicating their comprehension of the problem. Approximately 21% of students were capable of formulating problem-solving strategies, and 15% executed the calculations correctly. Interestingly, 11% of students double-checked their solutions. The students' responses reveal several challenges encountered during the mathematical problem-solving process, such as difficulty in understanding textual content, usage of mathematical terminology, establishing connections between problems, decision-making, uncertainty in problem resolution, time management, lack of attention to detail, and boredom. It is anticipated that the insights obtained from this research can guide teachers and educational practitioners in cultivating focus, discipline, and patience in problem-solving, while also assisting them in the selection of learning models tailored to the specific needs of their students.

INTRODUCTION

Problem-solving competencies are essential for all students, with mathematical problem-solving skills being of particular importance. These skills are vital due to the precise and logical calculations necessitated by mathematical problem-solving (Hallman-Thrasher, 2017; Verschaffel et al., 2020; Wake et al., 2016). Furthermore, the development of these skills fosters critical thinking (Schoenfeld, 2016), augmenting logical reasoning abilities that prove indispensable in everyday life, especially when making informed and effective decisions (Monteiro et al., 2020; Schoenfeld, 2016; Van Laar et al., 2017). Today's employers value individuals possessing robust problem-solving skills, particularly in STEM fields, where analyzing complex data and devising innovative solutions are crucial (Fan & Yu, 2017; Stanford et al., 2017). Moreover, mathematical problem-solving capabilities indicate adaptability and resilience in individuals (Alexopoulou et al., 2019; Ellis et al., 2017).

How to cite: Wahyuni., Zaiyar, M., Mazlan., Saragih, S., & Napitupulu, E. (2023). Students talk about difficulties they have in solving math problems. *Al-Jabar: Pendidikan Matematika*, *14*(1), 181-190.
E-ISSN: 2540-7562
Published by: Mathematics Education Department, UIN Raden Intan Lampung

Students often find themselves alone in their struggle to solve problems. Notably, difficulties are frequently encountered when tackling mathematical problems, especially in the domain of problem-solving. How students experience significant difficulties in this area as it demands an in-depth understanding and analysis of problems that goes beyond mere calculations (Dangle & Sumaoang, 2020). Research conducted in South Africa (Arends et al., 2017; Jäder et al., 2020) uncovered multiple challenges for students, such as concept comprehension, reading literacy, synthesizing reading content, and symbolic abilities - all key requirements for solving mathematical problems. Surya et al. (2017) emphasized that problem-solving skills in mathematics require students to identify known and unknown elements in problems, understand the sufficiency of the given elements, formulate mathematical models, devise effective strategies, and justify their solutions.

Several problem-solving models such as those developed by Polya, Krulik-Rudnick, and Hopfield & Tank provide various indicators and stages for problem-solving, including understanding the problem, planning solutions, executing the solution, and verification (Bernard et al., 2018; Fauza et al., 2022; Son et al., 2019; Tohir, 2019; Ford, 1994; Goyal et al., 2019; Hopfield & Tank, 1985). These indicators form a critical component in mastering mathematical problem-solving as they promote a systematic approach towards solutions, moving away from guesswork or intuition.

Nevertheless, previous research (Bernard et al., 2018; Nadhifa et al., 2019; Suryani et al., 2020) suggests that students' abilities cannot be thoroughly diagnosed and are constrained to analyses of problem-solving exercises, excluding students' responses to the problem-solving process. Consequently, this study seeks to delve deeper into students' mathematical problem-solving abilities and their reaction to the solving process. The aim is to accurately identify students' strengths and weaknesses in solving mathematical problems. By leveraging these assessments, educators can tailor their teaching methods to suit individual student needs and maximize their potential in mathematical problem-solving.

METHODS

This research is grounded in a descriptive qualitative approach and involves three junior high schools (SMP) in Aceh. School A was chosen based on its highest National Examination results in its cohort, comprising 26 students. Schools B and C were selected due to their commendable school accreditation status, with student bodies of 26 and 24, respectively. The selection of the research subjects was conscientiously made through deliberate sampling techniques. Each student involved in this study was chosen by mathematics teachers from their respective schools, given that teachers possess a deeper understanding of their students' capabilities. Consequently, the study incorporated a total of 76 eighth-grade junior high school students.

Table 1. Troubleshooting Ability Scoring Table

Aspects	Indicators	Score
Understanding the Problem	1. Write down the known, asked correctly and completely	3
	2. Write down the known, asked correctly but incompletely	2
	3. Miswriting the known, asked	1
	4. Not writing the catehui, asked	0

Planning	1.	Planning according to the correct procedure	3
	2.	Planning with correct but incomplete procedures	2
	3.	Making plans according to the procedure but wrong	1
	4.	Not planning	0
Problem solving	1.	Write settlement rules with correct and complete results	4
	2.	Write down settlement rules with correct but incomplete results	3
	3.	Write down settlement rules with incorrect but complete results	2
	4.	Write down settlement rules with incorrect and incomplete results	1
	5.	Not writing the problem solution	0
Checking Back	1.	Write the examination correctly and completely	3
	2.	Write down the inspection correctly and but incompletely	2
	3.	Write the inspection incorrectly	1
	4.	Not writing down the examination	0

Data collection was carried out through a triad of methods: tests, observations, and interviews. A scoring table was employed to assess problem-solving capabilities. The test material provided to students revolved around the topic of flat buildings, with attention given to ensuring validity, reliability, difficulty index, and discriminating power, thus making the questions viable for use. A comprehensive view of the research design can be observed in the following chart:

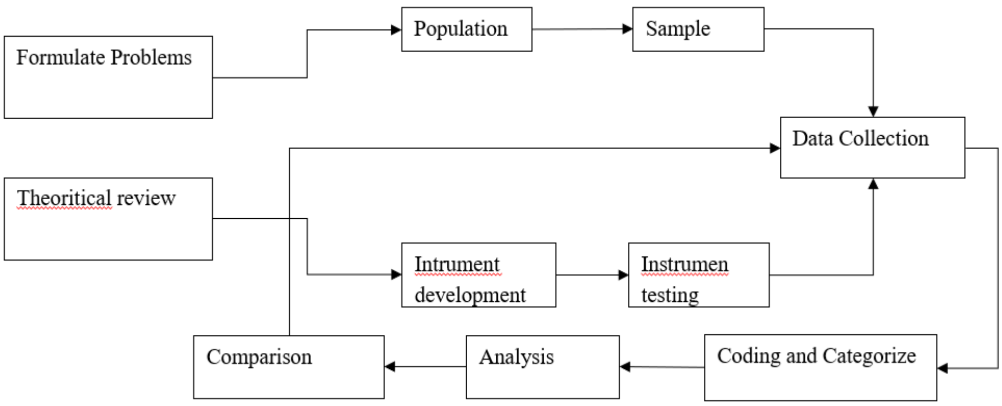

Figure 1: Qualitative research design

Observations were made as students tackled the test questions. The interview, meanwhile, was carried out in a focused manner, lasting sixty minutes. These interviews took place post the analysis of the students' problem-solving ability tests. The queries posed during the interview process were subsequently transcribed. In terms of data analysis, quantitative data was assessed descriptively using percentages, whereas qualitative data was descriptively analyzed via coding.

RESULTS AND DISCUSSION

This research commenced with problem-solving ability tests, followed by interviews with students. Examination of the problem-solving skills of 76 students across three schools revealed that 25% of students had documented what was known and asked for—an indicator of problem comprehension—, 21% were able to strategize for problem-solving, 15%

conducted correct calculations, and 11% rechecked their answers. These findings suggest that the problem-solving abilities of students remain below average.

Several students voiced their confusion about the starting point in resolving the assigned problems. Furthermore, the lengthy narrative questions necessitated literacy skills and intense concentration to complete, which led to 75% of students failing at the comprehension step, the first stage in the problem-solving process. Here are a few responses from students on the given problem-solving questions:

A1: "... I'm confounded by the problem, ma'am! The question is exceedingly lengthy, which leaves me uncertain about where to begin solving it and what material should be utilized..."

C23: "... I understand the material narrated in the question, but the connection between the known and the asked seems vague, ma'am."

Comprehension of questions is a critical aspect of problem-solving. Before solving a problem, the question must first be understood (Hopfield & Tank, 1985; Son et al., 2019). However, the extensive sentences and abundant information in the problem often confuse students regarding the problem's objective. They struggle to comprehend the question's purpose, leading to uncertainty about the actions required to tackle the problem (Alghazo & Alghazo, 2017; Deringöl, 2019).

Several factors contribute to students' misunderstanding of a given problem. Firstly, difficulties in understanding reading texts relate to students' limited language skills (Banse et al., 2017; Bragg et al., 2016; Hajer & Norén, 2017; Planas et al., 2018). This becomes evident when students struggle to comprehend a problem they read themselves, yet understand when read by the teacher.

Secondly, the use of mathematical terms unfamiliar to students presents an obstacle (Laurens et al., 2018). For example, students misunderstand the statement "the length of a circle's diameter equals twice its radius," but comprehend when it's written as $d = 2r$. This reflects a blindness to mathematical terms within the problem. Some students familiar with the terms can't construct mathematical models, converting everyday language problems into symbolic mathematical models.

Thirdly, students' inability to connect problems results in prolonged comprehension (Hadi et al., 2018). Consequently, it consumes more time than allocated, hindering their ability to solve all problems given by the teacher. Like the response given by the following students:

A27: "The question is lengthy, necessitating several readings to comprehend its meaning. Perhaps exam time can be extended."

Language and visual spatial skills play vital roles in comprehending mathematical problems (Aini et al., 2020; Wahyuni, 2022; Yang et al., 2019). Both are essential in understanding the goals. However, a lack of these skills impedes students' ability to understand the information and objectives outlined in the problem. This leads to misinterpretations of the problem's information, resulting in incorrect problem-solving decisions (Barwell, 2017; Riccomini et al., 2015).

Decision-making in the context of problem-solving, beyond mere understanding of the issue, presents a considerable challenge for students. Although they may successfully grasp the problem, the absence of a proper plan can prevent them from solving it. During the planning phase, students should devise a strategic approach that will guide them to an appropriate solution. To do so, they must draw from their information skills to structure a method for problem-solving. They need to know how to effectively organise the available information, identify the applicable concepts, discern the pertinent facts, and execute the operational procedures in a sequential order. However, according to our findings, only a meagre 21% of students demonstrated proficiency in these areas. The remaining majority, a staggering 79%, struggled to collate information and construct mathematical sentences necessary for resolving the issue. This deficit can be linked to their ability to form coherent visual perceptions, a skill grounded in logical thinking and visual-spatial abilities. If these abilities are lacking, students might struggle to differentiate, associate, and organise information effectively, thus impeding the troubleshooting process (Aini et al., 2020; Iwuanyanwu, 2021; Makamure & Jojo, 2021).

B17: "I'm baffled, there's an overwhelming amount of information in the question. It's challenging to decide what to prioritise and what information to disregard!"

B29: "Once I've discerned what's known and what's asked, I struggle to determine which formula to use. Sometimes there's an overload of information or, conversely, not enough to fit into the formula."

The above interviews highlight that student' often grapple with discerning the order of stages and finding missing values from existing data to input into formulas. Furthermore, they struggle to recall all relevant formulas and to identify connections between various materials. This can lead to errors and confusion in the problem-solving process. Difficulties in interpreting problems, constructing and relating conceptual aspects of mathematics due to incomplete knowledge and mastery of number facts can result in a wide array of mathematical skill deficiencies. This becomes particularly challenging when considering the hierarchical nature of the process; obstacles in understanding problems will subsequently cause failures in planning and execution of solutions (Caner et al., 2017).

Students' difficulties in planning problems can stem from a lack of proficiency in fact skills, numeracy, and information skills. Misinterpretations of the relationship between information and facts, as well as facts and formulas, can lead to errors when students substitute numbers into formulas, consequently leading to subsequent errors in the problem-solving process. Moreover, these skill deficiencies can result in inappropriate planning, as evidenced by the following student response:

A18 : "Solving standard mathematical problems is challenging enough, let alone those framed as word problems... After reading the problem, I often forget the content."

B5 : "Sometimes, after establishing the formulas, when I start substitifying the numbers into them, I'm at a loss as to how to proceed."

Students' uncertainties in problem-solving can trap them within their own problems, despite having conceived good strategic plans (Hadi et al., 2018). Effective planning necessitates confidence in the chosen solution as the best available option. However, this can be compromised by students' low abilities to transform formulas into different forms for correct problem-solving. This highlights the importance of a thorough understanding of arithmetic concepts.

Following the planning stage, the student's ability to correctly execute calculations is put to the test. A variety of factors can contribute to failures in solving mathematical problems: careless mistakes, lack of focus, inadequate preparation, or a poor understanding of foundational operational concepts. These factors can lead to errors during operations, difficulty in resolving problems, and struggles in applying mathematical concepts. Unsurprisingly, students are often unaware of the mistakes they commit, as shown in this interview excerpt:

C23: "Was my answer incorrect? Why? I thought I had calculated it correctly. Could I have another look?"

Certain students encounter errors when performing calculations due to insufficient preparation or a lack of understanding regarding crucial mathematical concepts and principles, which they forget (Ulya et al., 2023). Their ability to recall significant details such as concepts, tables, and calculation methods becomes impaired, leading to uncertainty, procedural mistakes, and incorrect outcomes. Interestingly, while some students commit computational errors, they are often able to rectify these when given a chance to revisit their work. This reveals that students possess the ability to carry out calculations effectively, yet errors and failures in basic operations frequently stem from their lack of attention and focus during the problem-solving process.

In truth, a reduction in such carelessness could be achieved if students consistently reviewed and sought clarity in their completed work. For example, a student labeled C23 was able to identify and correct their errors upon being given the opportunity to re-examine their work. Despite the correctness of their initial attempt, neither this student nor others deemed it necessary to review their work. This oversight prompted an interview with 4% of the students, revealing the following results:

B13: "Is it really necessary to cross-verify? It's already exhausting, if the answer is wrong, it means I have to redo everything."

C5: "I don't have time to double-check; cross-verification of calculations tends to consume more time. Hence, it's best to assure the answer is correct in the first place."

Evidently, the initial stages of problem-solving are challenging and taxing for students, making the validation stage seem redundant. They perceive completing the first three stages as a victory in itself. This perspective, however, is flawed since, like student C23, they may misinterpret the problem or commit inadvertent errors. Some students acknowledged that the time-consuming nature of problem-solving leads to boredom once they've found an answer, and their curiosity about the solved problem dissipates, supplanted by a sense of satisfaction and accomplishment (Hannula, 2015). This satisfaction discourages them from revisiting the same problem, as they fear losing their sense of achievement if their solution proves incorrect. The findings suggest that besides boredom, students harbor a fear of failure and struggle to delay gratification, lacking the patience to progress to the subsequent steps. Yet, problem-solving skills can be refined and enhanced through consistent practice and dedication.

Following the successful resolution of a problem, students experience a surge in the dopamine hormone, signifying their brain's appreciation for the completed task (Eliot & Hirumi, 2019). However, students tend to linger in this state of elation, thereby hindering the progression to the next stage of problem-solving. In this respect, a student's psychological state significantly influences the execution of Stage 4. Therefore, exploring the psychological implications on students' problem-solving capacities, an aspect not covered in this study, is a pivotal future research area.

CONCLUSIONS

The study, encompassing 76 students from three different schools, revealed that only 25% of the students correctly identified the problem's parameters and requirements, a clear indicator of problem understanding. Merely 21% were able to strategize a plan for problem-solving, 15% executed their calculations without errors, and only 11% took the effort to verify their results. Such data points suggest a below-average proficiency in problem-solving among the student population. Based on the interviews conducted, students reported multiple challenges in tackling mathematical problems. These included difficulties in comprehending reading texts, grappling with mathematical terminology, inability to draw connections between problems, indecisiveness in selecting problem-solving strategies, lack of confidence, time constraints, negligence, and boredom. It is hoped that these findings will provide useful insights for educators and practitioners in their efforts to foster focus, discipline, and patience in students during problem-solving tasks, and in tailoring learning models to suit their students' unique needs.

Proficiency in problem-solving is a skill that can be refined and enhanced over time through consistent effort and practice. The researchers deduce that emotional aspects significantly influence students' problem-solving process. Nonetheless, this study has not delved into the psychological impacts experienced by students while tackling problems. Thus, it is anticipated that future researchers will address this gap by exploring the psychological and emotional effects of the process of solving mathematical problems on students.

AUTHOR CONTRIBUTIONS STATEMENT

All authors contributed to design research, process question analysis, data analysis, manuscript writing, and final manuscript approval.

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