Original Research Article

Solving Mathematics Problems Based on Visual Information Processing

Abstract

Solving mathematical problems involves a complex process and requires the ability to comprehend and manipulate visual information. When an individual encounters a problem, the ability to represent data, plan solution steps, and visualize relationships between variables is crucial. This research aims to explore in-depth how visual information is processed during mathematical problem-solving. The findings indicate that Subject S1, with high visual ability, adeptly represents the problem, articulates known and unknown elements, and exhibits a strong conceptual understanding. Students with robust visual conceptualization skills can plan and solve problems using elimination and substitution methods. Verifying results using different methods reflects a solid conceptual understanding. On the other hand, Subject S2, with low visual ability, struggles to represent the problem and tends to focus directly on the solution. This suggests a lack of conceptual understanding, limitations in visual representation, and deficiencies in verification skills. In conclusion, teachers need to enhance students' conceptual understanding, metacognitive awareness, and practice verification skills to develop their mathematical problem-solving abilities.

Keywords: Solving mathematics problems; Visual information processing; Linear equation in two variables

1. INTRODUCTION

In the 21st century, problem-solving has been recognized as a crucial competency that students need to possess (Makiyah et al., 2021; Zubaidah, 2016). Several countries emphasize problem-solving as a vital skill that students should acquire in their curriculum, including Indonesia (NCTM, 2000). Contemporary problem-solving models assert that a key element in the problem-solving process is understanding the form of the problem representation presented in assessments (Bruning et al., 2012). Therefore, this understanding is considered essential because effective problem-solving requires individuals to analyze problems, recognize patterns, and design effective solution strategies. In this context, precision in understanding the structure and content of problems becomes a foundational element for success in solving problem-solving tasks in everyday life. There are four key steps in problem-solving: (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, and (4) looking back(Polya, 1973).

Solving mathematical problems requires a set of cognitive skills, including in-depth visual information processing. When students encounter mathematical problems, they often need to create visual representations of the given information, such as diagrams, graphs, or mathematical models, to better understand the problem. A profound understanding of how visual information is processed in this context can provide valuable insights into the cognitive mechanisms involved and lay the foundation for the development of more effective teaching methods.

Furthermore, in solving mathematical problems, visual information plays a crucial role in helping students organize information, identify patterns, and formulate solution strategies. This visual information processing involves the brain in recognizing, interpreting, and connecting visual elements to form a deep understanding of the mathematical problems at hand. Therefore, visual representations of mathematical concepts provide a strong foundation for long-term mathematical understanding(Danial, Upu & Ihsan, 2023).

Visual thinking plays a significant role in the understanding and reviewing stages of mathematical problem-solving(Darmadi & Handoyo, 2016). This aligns with Ulya's research(2015), indicating a high-level positive correlation between students' cognitive styles and their problem-solving abilities. The correlation coefficient of 0.624 suggests a significant relationship, while the determination coefficient of 0.390 indicates that approximately 39% of students' problem-solving abilities are influenced by cognitive styles.

Previous studies have provided insights into the importance of visual thinking, visual information processing, and cognitive styles in understanding

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and enhancing students' cognitive abilities in the context of problem-solving. However, they have not specifically addressed differences in visual information processing abilities among individuals, such as visual clarity, and sensitivity to visual representations, which can influence how someone integrates visual information when solving mathematical problems.

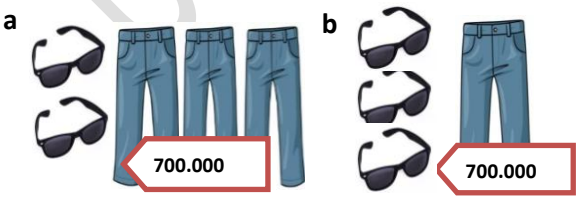
This understanding provides a foundation for the development of more focused learning strategies that support the enhancement of students' problem-solving skills, especially in the context of visual information processing. Thus, the relationship between visual thinking and visual information processing forms a crucial basis for mathematical problem-solving, where these two aspects mutually support and complement each other to achieve better understanding and effective solutions. Therefore, new innovations in teaching are needed to ensure that the understanding process can proceed effectively (Danial, Faisyah, 2021; Danial & Azmy, 2022).

This study aims to explore more deeply how visual information is processed during mathematical problem-solving. With a focus on cognitive levels and the generated visual representations, this research will provide a more profound understanding of the dynamics of cognitive processes during mathematical problem-solving.

2. METHODS

This research employs an exploratory qualitative approach. The subjects in this study are students selected using purposive sampling techniques, specifically those with high and low visual abilities from the eighth-grade students of Junior High School of 1 Sinjai who are currently learning the material on a system of linear equations with two variables. This involves presenting non-routine problems to the students;Pay attention to the followingpicture

Picture 1 :Question



Based on the picture, how much the price if one glasses and two pants?

3. RESULT AND DISCUSSION

3.1 Subject S1

Subject S1 with high visual ability is able to represent the problem well by writing down the known and asked elements. This is because during the process of analyzing the problem, the student is capable of capturing visual details with a high level of accuracy and efficiently recognizing and understanding visual patterns. The following is the presented solution result of Subject S1.

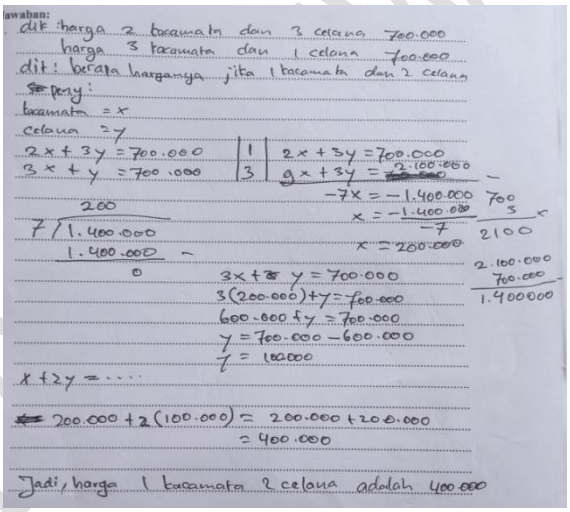


Figure 1. S1's outcome of completing the task.

When planning the solution, Subject S1 with high visual ability rewrites the solution plan by including assumptions, where glasses are denoted as x and pants as y, along with a mathematical model. Subsequently, Subject S1 proceeds with the solution steps using the elimination and substitution methods. Afterward, the subject writes a conclusion. When Subject S1 double-checks using a different solution method, they are able to find the same values or results. This indicates that Subject S1 has a good understanding of the concepts, recognizes the importance of verification, and possesses strong metacognitive skills in checking for accuracy.

3.2.Subject S2

Subject S2, with low visual ability, does not represent the problem, neither by writing down the known information, the questions, nor providing examples. Subject S2 immediately focuses on solving the problem. This indicates that Subject S2 lacks a strong understanding of visual concepts, meaning the ability to comprehend and represent information visually.

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The lack of experience or practice in understanding and creating visual representations can limit Subject S2's ability to tackle problems involving visual aspects. Creating visual representations often involves creative elements. Insufficient creative skills or visual imagination can make it challenging for Subject S2 to produce accurate representations. Subject S2 is indicated to have a learning style that is more dominated by auditory or kinesthetic aspects, which can reduce preferences or capabilities in visual representation. The following presents the solution results of Subject S2.

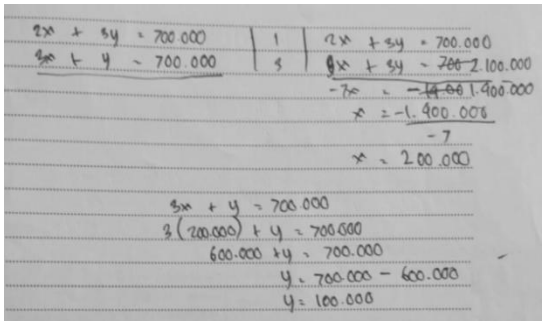

Figure 2. S2's outcome of completing the task.

When Subject S2 goes through the steps of the solution process, Subject S2 can only find the values of variables x and y. The subject is unable to answer the question perfectly based on the core question of the problem, which is $x + 2y =$...?. Subject S2 also fails to perform a proper evaluation of correctness. This could be indicated by the lack of understanding of the concept of a system of linear equations with two variables, a lack of awareness of the importance of verification, a deficiency in skills or strategies to effectively test the accuracy of answers. This might result from a lack of skills in substitution, matching answers with initial conditions, or using other verification methods. Additionally, there is a deficiency in the metacognitive skills of the student. Awareness of thinking processes (metacognition) might be lacking, leading to a lack of realization of the importance of verifying answers. Furthermore, there is a lack of in-depth understanding or reflection on the problem-solving process.

For address this, it is crucial to develop a deeper understanding of the concepts, enhance metacognitive awareness, and provide training in verification skills for students. Involving students in a reflective problem-solving process can assist them in comprehending the significance of testing the accuracy of their answers. This research is expected to aid educators in constructing an understanding of the relationship between visual information processing and mathematical problem-solving abilities. By focusing on the visual aspect in the context of problem-solving, this study provides profound insights into how individuals with high and low visual abilities interact with mathematical challenges. Further research could explore various visual strategies employed by individuals with high visual abilities and how these strategies can be integrated into the learning context in the classroom.

4. CONCLUSION

The conclusion from these findings research is that the development of mathematical problem-solving skills requires attention to the visual aspects, especially in terms of conceptual understanding, visual representation, and verification skills. Students need to be encouraged to build strong mental images and be aware of the importance of critically verifying solution results. Therefore, strengthening the visual aspects is essential to enhance the effectiveness of mathematics learning.

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References

1. Bruning, R. H., Schraw, G. J., Norby, M. M., & Ronning, R. (2012). Psicologia cognitiva y de la instrucción. Pearson Educación Ciudad de México.
2. Rustam, F. R., Danial, D., Syarifuddin, S., & Fitriani, F. (2022). Analysis of Student Learning Difficulties in Solving MI/SD Mathematics Problems in the Madrasah Ibtidaiyah Teacher Education Study Program. JTMT: Journal of Tadris Mathematics, 3(2), 76-90.
3. Danial, Upu, H., & Ihsan, H. (2023). Unraveling The Information Processing in Mathematics Learning Based on Learning Style Preferences. Himalayan Journal of Education and Literature, 4(6), 21–27. https://doi.org/10.47310/Hjel.2023.v04i06.004
4. Danial, D., & Azmy, N. (2022). Effectiveness of Application of Statistics Board Teaching Media to Mathematics Learning. Proceedings of the National Seminar on the Faculty of Tarbiyah and Teacher Training IAIM Sinjai, 1, 15–19.
5. Darmadi, D., & Handoyo, B. (2016). Visual thinking profile of prospective mathematics teacher students with a visual learning style in solving trigonometry problems. Math Educator

Nusantara Journal: A Vehicle for Publication of Scientific Writing in the Field of Mathematics Education, 2(1).
6. Makiyah, Y. S., Mahmudah, I. R., Sulistyaningsih, D., & Susanti, E. (2021). The Relationship between 21st Century Communication Skills and Problem Solving Skills of Physics Education Students. Journal of Teaching and Learning Physics, 6(1), 1–10. https://doi.org/10.15575/jotalp.v6i1.9412
7. NCTM. (2000). Standards for School Mathematics. Reston, VA: National Council of Teachers of Mathematics.
8. Polya, G. (1973). How to Solve it. Second Princeton Paperback Printing. Princeton: Princeton University Press.
9. Ulya, H. (2015). The Relationship between Cognitive Style and Students' Mathematical Problem Solving Ability. GUSJIGANG Counseling Journal, 1(2).
10. Zubaidah, S. (2016). 21st Century Skills: Skills Taught Through Learning. National Seminar on Education, 2(2), 1–17

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