M A T H L I N E
JURNAL MATEMATIKA DAN PENDIDIKAN MATEMATIKA
ISSN 2502-5872 (Print)
ISSN 2622-3627 (Elektronik)

Volume 10 Number 3, August 2025, 801-816

AN ANALYSIS OF ELEVENTH-GRADE STUDENTS' MATHEMATICAL PROBLEM-SOLVING ABILITIES IN CONTEXTUAL CIRCLE PROBLEMS

Salwa[1], Nurina Hidayah[2], Anie Faye M. Aribuabo[3]
[1,2]Departement of Mathematics Education, Pekalongan University, Central Java, Indonesia
[3]Early Childhood and Special Needs Education Department, Mariano Marcos State University, Batac City, Philippines
*Correspondence: nurihidayah.matematika@gmail.com

ABSTRACT
The low ability of students in solving non-routine problems highlights the importance of examining their mathematical problem-solving abilities in contextual circle problems. Problem-solving ability refers to how individuals utilize their knowledge and skills to handle unfamiliar situations. These abilities are analyzed based on five indicators proposed by Krulik and Rudnick: read and think, explore and plan, select a strategy, find an answer, and reflect and extend. This study employed a descriptive qualitative method with data collected through written tests and semi-structured interviews. Data were analyzed using the Miles and Huberman model. The test instrument consisted of three contextual circle problems with different levels of guidance: complete guidance, brief guidance, and no guidance. The results show that students' problem-solving abilities varied across each problem. In the first problem, most students from all categories were able to complete the task according to the indicators, although errors occurred in the calculation and reflection stages. In the second problem, one student in the moderate category showed a decline from the planning to the reflection stage, while students in the low category experienced a more significant drop. In the third problem, only students in the high category consistently showed good abilities, while moderate and low-category students struggled in nearly all stages. One student in the low category even made no attempt to solve the problem. Students' problem-solving profiles are reflected through their successes and obstacles in carrying out the five problem-solving stages.
Keywords: Contextual Circle Problems, Krulik dan Rudnick Indicators, Problem-Solving Ability

How to Cite: Salwa, Hidayah, N., & Aribuabo, A. F. M. (2025). An Analysis Of Eleventh-Grade Students' Mathematical Problem-Solving Abilities In Contextual Circle Problems. *Mathline: Jurnal Matematika dan Pendidikan Matematika, 10*(3), 801-816. http://doi.org/10.31943/mathline.v10i3.956

PRELIMINARY

Students' mathematical abilities include not only computation but also logical and critical thinking in solving problems. Solving mathematical problems is a complex cognitive ability that requires understanding the problem and applying mathematical concepts (Amalina & Vidákovich, 2023b). According to Alsina et al. (2024), mathematical problem solving is one of the main goals of mathematics In the 2012 PISA assessment, it is defined as the ability to understand and solve situations where the solution is not immediately

apparent (Csapó & Molnár, 2017). Mathematical problem solving refers to a thinking process that involves understanding the problem situation and applying mathematical knowledge to reach a solution (Amalina & Vidákovich, 2023a). According to Isfahani et al. (2024), Krulik and Rudnick (1988, 1995) stated that problem-solving ability is the process of using one's knowledge, skills, and understanding to resolve unfamiliar situations. Krulik and Rudnick (1995), proposed five interrelated steps in the problem-solving process: read and think, explore and plan, select a strategy, find an answer, and reflect and extend (Suryaningsih, 2019). Siswanto & Ratiningsih (2020), also argue that problem-solving ability is effective when students can comprehend information, design a plan, follow systematic steps, and correctly apply mathematical concepts to draw accurate conclusions related to contextual problems.

One type of problem closely related to problem solving is the contextual problem. This type of question represents real-life situations encountered in daily life (Chavarría-Arroyo & Albanese, 2023). According to Lomibao et al. (2017), students tend to solve a problem by relying on their prior understanding and knowledge until they are able to provide an answer or interpretation of the given situation. Word problems are a common form of contextual problems that present a scenario and a question, where the answer is obtained through the application of mathematical operations (Vessonen et al., 2025). Although contextual problems are intended to support understanding, many students still struggle to solve them. In relation to problem solving, scaffolding can be provided through student worksheets designed with embedded directions or instructions that encourage students to think, thus helping them better understand and solve the contextual problems presented (Arifin et al., 2020). On the other hand, students often dislike mathematics because they perceive it as difficult, full of formulas, and confusing (Rayhan & Juandi., 2023). This difficulty becomes a barrier to achieving optimal learning outcomes (Rayhan et al., 2025). One of the mathematical topics frequently considered difficult by students is the topic of circles.

A circle is a closed curve where all points on the curve are equidistant from the center. The curved line in this definition can be understood as a closed curve, thus a circle is considered a two dimensional shape in a plane (Utami et al., 2022). The concept of the circle is taught from elementary school through high school and is closely related to daily life, so solving problems related to circles requires problem-solving skills (Sholihah *et al.*, 2024). Nevertheless, many students have not yet fully understood the basic concepts of circles. This is evident from their errors in determining the area and circumference of circles or in

accurately visualizing the shape of a circle (Mustaghisa & Chandra, 2024). Thus, the topic of circles presents a unique challenge, particularly when students make frequent errors in distinguishing between radius and diameter, or applying formulas for area and circumference correctly.

Observations in Grade XI at SMA Islam Pekalongan indicate that many students still face difficulties in following systematic steps in mathematical problem solving, particularly in designing appropriate strategies and identifying key information in the problems. These difficulties reflect a weak conceptual understanding, consistent with Indonesia's 2022 PISA mathematics score of 366, which falls below the minimum proficiency level required for solving basic mathematical problems (OECD, 2023). Therefore, this study aims to describe the profile of students' mathematical problem-solving abilities in contextual circle problems, with the goal of contributing to the improvement of mathematics learning quality.

METHODS

This study employed a descriptive qualitative method to analyze students' mathematical problem-solving abilities in answering contextual circle problems based on Krulik and Rudnick's stages. Qualitative research aims to examine phenomena in natural settings with the researcher acting as the primary instrument (Safrudin et al., 2023). According to Waruwu (2023), the qualitative approach is both descriptive and analytical. Descriptive refers to portraying and explaining events, phenomena, and social situations, while analytical involves interpreting, giving meaning to, and comparing the research data.

The study was conducted at SMA Islam Pekalongan, involving six 11th-grade students in the second semester of the 2024/2025 academic year, selected through purposive sampling. Data were collected through tests and semi-structured interviews developed based on the five indicators of mathematical problem-solving abilities according to Krulik and Rudnick: read and think, explore and plan, select a strategy, find an answer, and reflect and extend. The Krulik & Rudnick model was chosen for this study because it is considered more suitable for non-routine or contextual problems, while the Polya model tends to be more appropriate for routine problems (Tohir et al., 2018). The test consisted of three contextual essay questions on the topic of circles, each with different levels of guidance (complete, brief, and none), aiming to explore students' abilities based on the indicators. Before implementation, the test instrument was validated by three experts to ensure the suitability of each item with the predetermined indicators. Content validation was conducted as this study is descriptive qualitative, where the researcher acts as the main instrument. Validation

data were tabulated and analyzed using Aiken's V formula, resulting in a score of 0,823. The validity criteria refer to Sensus *et al*., (2022), who stated that an instrument is considered valid if the index value falls within the range of $0{,}40 < V \leq 0{,}60$ or higher. Thus, the instrument in this study is declared valid and appropriate for use.

The interview aimed to explore in greater depth the students' thinking processes and strategies in solving contextual problems involving circles, guided by a framework based on the five indicators of Krulik and Rudnick. The read and think stage examined students' understanding of the information and questions in the problem. Explore and plan investigated their initial plans, such as the use of diagrams. In select a strategy, students explained the strategy they chose and their reasoning. Find an answer focused on the process of constructing a solution and performing calculations, while reflect and extend evaluated the students' answers, their awareness of mistakes, and the potential for applying the strategy to similar problems. Students' abilities were analyzed using a scoring rubric on a 0–3 scale for each indicator, based on an adaptation from the study by (Sesa et al., 2022). Thus, the maximum score for each problem was 15. The final score was calculated using the following formula:

$$\text{Final Score} = \left(\frac{Student's\ Score}{Maximum\ Score}\right) \times 100$$

The data obtained from the study were collected, categorized, and processed to produce a description of the problem-solving ability categories, as presented in Table 1.

Table 1. Categories of Problem-Solving Ability

Category	Score Interval	Range of Scores
High	$x \geq 76$	$76 - 100$
Moderate	$55 < x < 76$	$55{,}01 - 75{,}99$
Low	$x \leq 55$	$0 - 55$

(Sesa *et al*., 2022)

The qualitative data analysis in this study followed the stages proposed by Miles and Huberman (1992), data reduction, data display, and conclusion drawing. The reduced data included test results and interviews related to students' thinking processes in solving contextual circle problems, which were then sorted according to ability categories (high, moderate, low) to enable more focused analysis. Data display refers to the process of organizing information in a way that facilitates the drawing of conclusions in qualitative research. Data can be presented in the form of brief descriptions, diagrams, or other formats (Zulfirman, 2022). The data collected in this study came from mathematical problem-solving test instruments and semi-structured interviews. All of these data were then processed and presented in written form for further analysis. In this study, conclusion drawing was carried

out through the following steps: 1). Reviewing all data based on the indicators of mathematical problem-solving ability as proposed by Krulik and Rudnick; 2). Formulating preliminary conclusions based on the initial analysis of students' responses to contextual problems on circles; 3). Drawing final conclusions based on in depth analysis of the test results according to the indicators and students' ability categories.

RESULT AND DISCUSSION

Based on students' scores, mathematical problem-solving abilities were categorized into three groups: high, moderate, and low. Differences in ability were observed through the students' work on three contextual circle problems, which were analyzed using the indicators proposed by Krulik and Rudnick.

A. Research Result

1) Analysis of Data on Problem 1

The first problem provided complete guidance and asked students to determine the equation of a miniature garden circle based on the given diameter and the center point of the original garden. In the read and think stage, students identified key information in the problem. The explore and plan stage involved calculating the radius of the miniature garden. In select a strategy, students chose the general formula for the equation of a circle. During find an answer, they substituted the values into the formula and performed the calculation. Finally, in the reflect and extend stage, students concluded the equation form as the final answer. This problem assessed students' ability to construct a mathematical model from a real-world context with the support of structured steps.

a) Data Result in the High Category

Based on the data analysis, the test results of students in the high category namely students T5 and T6 are presented. In the fourth indicator, student T5 made an error in the final calculation by writing the result of the squared radius substitution as 122 = 122, whereas it should have been 144. In the fifth indicator, T5 was able to write a conclusion consistent with the result of substituting the squared radius into the circle equation. This indicates that despite a calculation error, the student was still able to reflect and connect the result to the correct concept. Meanwhile, student T6 did not rewrite the formula as instructed but was able to perform the calculation accurately due to a thorough understanding of the concept. This shows that strong conceptual mastery enables students to solve problems systematically. Overall,

students in the high category were able to solve the problems well, although there were still some issues with calculation accuracy and consistency in presenting the results.

b) Data Results in the Moderate Category

The following presents the test analysis of moderate-category students S1 and S2:

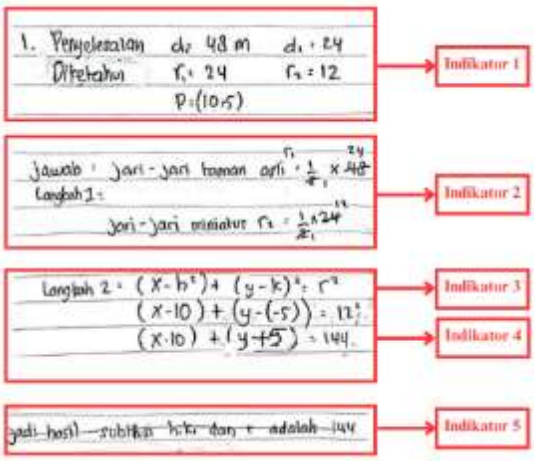

Figure 1. S1's Test Result

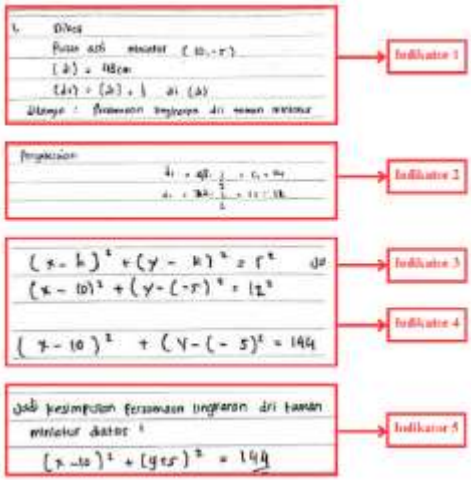

Figure 2. S2's Test Result

The analysis of students S1 and S2 reveals a difference in their level of achievement. In the first indicator, S1 was able to write the given information correctly but did not include the part of the question being asked, resulting in an incomplete understanding of the problem. In the second indicator, S1 was able to determine the radius of both the original park and the miniature, but the presentation of the steps lacked order and systematic structure. In the fourth indicator, although the value substitution was correct, S1 did not complete the procedure to the final step. A fairly significant error was found in the fifth indicator, where S1 wrote a conclusion that did not match the calculation result. On the other hand, S2 showed better performance across the indicators. Although the written steps in the second indicator were unclear, the interview revealed a strong conceptual understanding. Therefore, it can be concluded that S2 demonstrated better problem-solving skills than S1, as S2 was able to understand the problem, follow the instructions carefully, and complete the process through to the conclusion. Meanwhile, S1 still experienced confusion in understanding the question and in formulating an accurate final conclusion.

c) Data Results in the Low Category

The following presents the test analysis of low-category students R1 and R2:

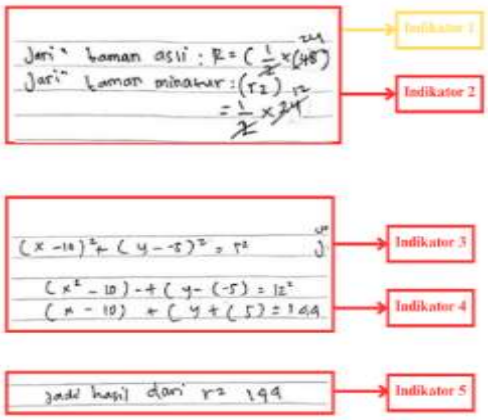

Figure 3. R1's Test Result

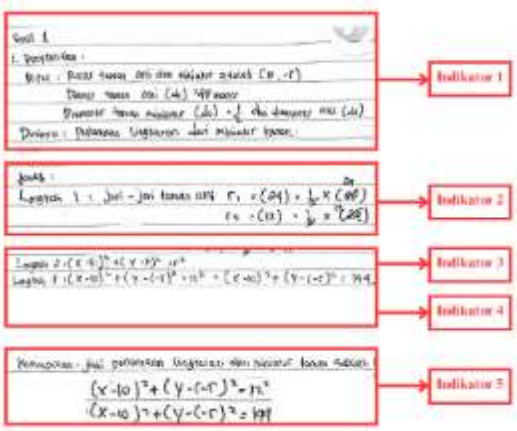

Figure 4. R2's Test Result

Overall, both R1 and R2 were able to fulfill the second and fourth indicators successfully. They accurately determined the radius of the park and correctly performed value substitution to obtain the expected results. However, inconsistencies were observed in the remaining indicators. In the first indicator, R2 systematically wrote down the known and asked information, whereas R1 demonstrated only a visual understanding without documenting it. Regarding the third indicator, R2 stated the formula before substitution, while R1 directly substituted the values without including the formula. In the fifth indicator, R2 formulated a consistent conclusion, although it was not yet simplified, while R1 provided a conclusion that did not correspond to the calculated result. Based on the test and interview findings, R2 exhibited a more systematic problem-solving process compared to R1.

2) Analysis of Data on Problem 2

The second problem provided brief guidance, in which students were asked to calculate the circumference and area of a circular pond based on a given equation. In the read and think stage, students identified the center and radius from the standard equation. The explore and plan stage involved determining the radius by taking the square root. In select a strategy, students chose the formulas for circumference and area of a circle using $\pi = 3.14$. In find an answer, they performed the calculations based on the formulas, and in reflect and extend, they concluded the results along with appropriate units. This problem assessed students' ability to interpret an equation and apply it in a geometric context.

a) Data Results in the High Category

Both students T1 and T2 were able to fulfill most of the indicators of mathematical problem-solving ability. They successfully determined the radius of the circle, applied the formulas for circumference and area before performing

calculations, and executed the calculations accurately. Their written responses and explanations during the interviews reflected a solid understanding of the problem-solving process. However, T2 did not state the question being asked in the first indicator and only focused on the given information. During the interview, T2 admitted that this occurred due to a lack of careful reading of the problem. In the fifth indicator, T2 only included the result of the circumference in the conclusion, omitting the area, even though both were required. T2 was unaware of this omission until it was pointed out during the interview, indicating a weakness in reviewing the final answer. In contrast, student T1 demonstrated a complete solution that aligned with all indicators, including stating both the known and required information, concluding with a complete sentence, and writing the correct units. This difference suggests that while T2 has a good conceptual understanding of the necessary steps, improvement is needed in terms of accuracy and awareness in presenting all essential elements of the solution.

b) Data Results in the Moderate Category

The following presents the test analysis of moderate-category students S1 and S2:

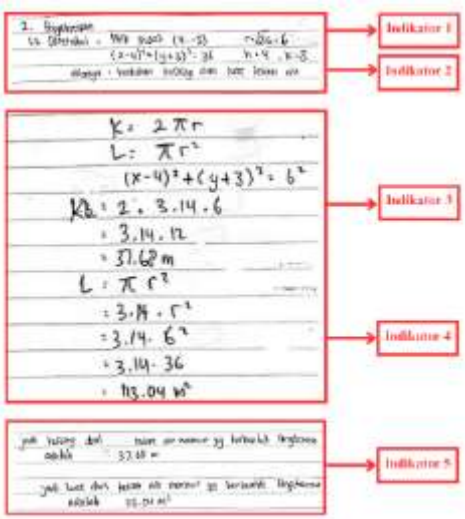

Figure 5. S1's Test Result

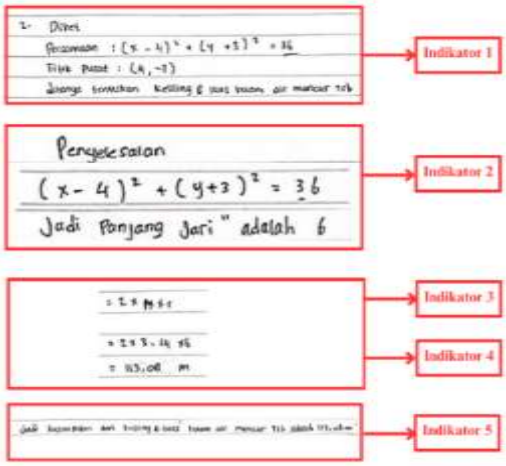

Figure 6. S2's Test Result

In general, both S1 and S2 met most of the indicators, particularly in the initial stage of understanding the problem. In the first indicator, both students were able to identify the given information, such as the center point and the form of the equation, and understood what was being asked. In the second indicator, S1 demonstrated a well-structured process in determining the radius from the given equation. S2 also identified the radius correctly but did not show the calculation process, indicating limited elaboration of their thinking. Regarding the third indicator, S1 wrote the

formulas for both circumference and area completely, while S2 only included the formula for circumference, suggesting a lack of mastery in selecting appropriate strategies.

In the fourth indicator, S1 carried out the calculations for both circumference and area correctly. In contrast, S2 only calculated the circumference, and the result was incorrect due to an error in decimal multiplication. In the fifth indicator, S1 provided a complete conclusion, including appropriate units and both results, whereas S2 only stated the circumference and mistakenly used that value as the area without further calculation, resulting in an inaccurate conclusion. These findings highlight a difference in the completeness of the process and accuracy of the final answer. S2 appeared to struggle with recalling formulas, lacked precision, and did not review their work, indicating the need for further guidance to improve accuracy and systematic thinking skills.

c) Data Results in the Low Category

The following presents the test analysis of low-category students R1 and R2:

Figure 7. R1's Test Result

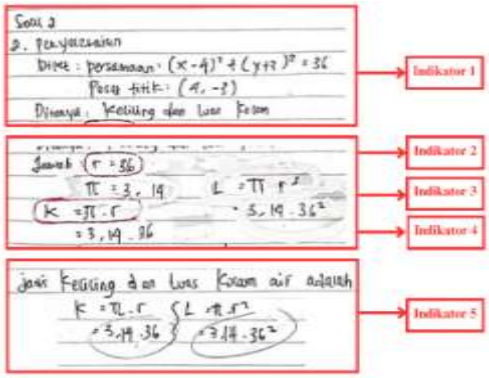

Figure 8. R2's Test Result

In the first indicator, both respondents were able to correctly identify the given and asked information in the problem. However, in the second indicator, both made a conceptual error by interpreting the value 36 in the equation as r instead of r^2, thus failing to extract the square root and directly writing r = 36. R2 did not realize this mistake until the end of the problem, while R1 recognized the error when beginning the calculation process. In the third indicator, R2 incorrectly stated the formula for circumference and was only accurate in the area formula, indicating a lack of mastery of basic formulas. In contrast, R1 correctly wrote both formulas, aided by the guidance provided in the question.

For the fourth indicator, R2 did not complete the calculation properly due to uncertainty about the radius value and difficulty handling decimal numbers, resulting

in an incorrect final answer. Conversely, although R1 initially wrote r = 36, they used the correct radius (r = 6) during the calculation, leading to an accurate result. In the fifth indicator, R2 was unable to provide a complete and correct final conclusion, as they lacked confidence in their calculations and had not properly finished the problem. Meanwhile, R1 was able to compose a complete and accurate conclusion aligned with the final result. Overall, although both students made an initial error in determining the radius, R1 was able to correct the mistake and solve the problem more effectively, thus demonstrating stronger mathematical problem-solving ability compared to R2.

3) Analysis of Data on Problem 3

The third problem did not include any guidance, so students had to independently construct the equation of a circle using information about the center and diameter of the pond, then convert it into general form. In the read and think stage, students understood the initial information. During explore and plan, they gradually determined the radius. The select a strategy stage involved choosing the equation formula for a circle. Next, in the find an answer stage, students substituted the values and simplified them into standard form. Finally, in the reflect and extend stage, they converted the equation into general form and checked the result. This problem assessed students' ability to formulate strategies and solve problems without any solution guidance.

a) Data Results in the High Category

Student T1 demonstrated full achievement across all indicators of mathematical problem-solving ability. The student understood the problem well, highlighted key information, and supported their understanding with prior knowledge. The solution steps were written completely and neatly, accompanied by a clear final conclusion. Student T2 also showed strong performance, successfully identifying important information and arriving at the correct answer. However, T2 did not write down what was being asked in the problem and provided an incomplete calculation process, particularly in determining the radius. The strategies and conclusions written were also less detailed compared to those of T1. Overall, T1 demonstrated a more systematic and complete problem-solving ability than T2. Based on interview results, T1 followed the problem instructions thoroughly, while T2 tended to skip certain steps due to feeling confident in their understanding of the task.

b) Data Results in the Moderate Category

The following presents the test analysis of moderate-category students S1 and S2:

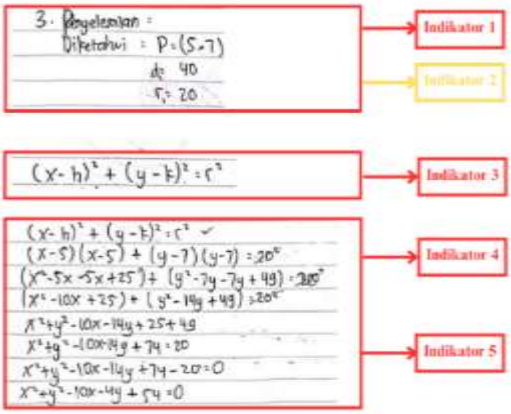

Figure 9. S1's Test Result

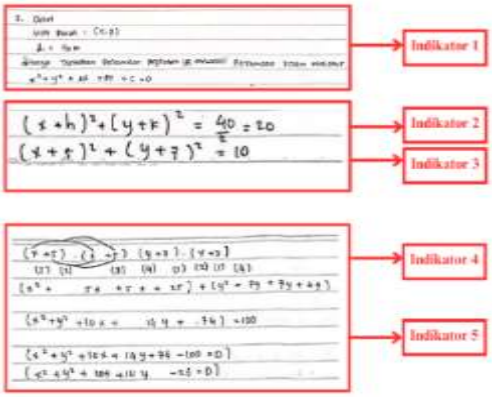

Figure 10. S2's Test Result

In problem number 3, Student S2 was able to meet the first and second indicators by clearly writing down the given information and correctly determining the radius. However, in the third and fourth indicators, errors occurred in selecting the appropriate formula and performing the substitution calculation, resulting in an incorrect answer. In the fifth indicator, S2 was unable to properly transform the equation form and failed to state the conclusion clearly. Meanwhile, Student S1 fulfilled the third indicator by correctly writing the formula, but did not meet the first and second indicators due to not stating the question and failing to determine the radius. This mistake also affected the outcomes in the fourth and fifth indicators, where the calculation and conclusion were inaccurate. Therefore, although both students received the same score, S2 demonstrated a stronger understanding of the initial concept, while S1 tended to rely on memorizing formulas without fully comprehending the problem context.

c) Data Results in the Low Category

Only respondent R16 attempted problem number 3, while respondent R13 did not complete the task due to perceiving it as too difficult; thus, none of the indicators were achieved. The following is an analysis of the test and interview data from respondent R1.

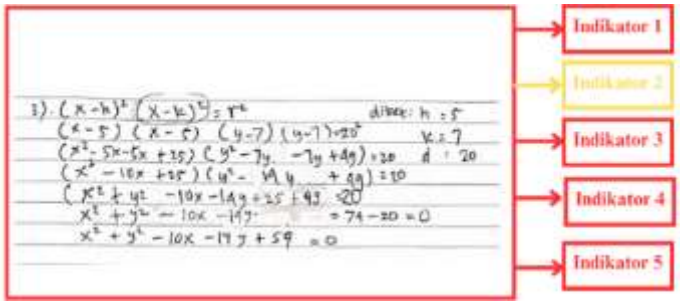

Figure 7. R1's Test Result

Respondent R1 demonstrated inconsistencies across nearly all indicators. For the first indicator, R1 only wrote the information about the center point and the original diameter without stating what was being asked. In the second indicator, R1 failed to determine the radius of the miniature pond due to confusion caused by the absence of guidance. In the third and fourth indicators, errors occurred in both the use of formulas and calculations due to the incorrect radius value. For the fifth indicator, R1 was unable to transform the equation correctly and did not write a conclusion due to confusion. In general, both students in the low-ability category experienced difficulties in understanding the problem, planning solution steps, and composing accurate calculations and conclusions. These difficulties were influenced by confusion, lack of focus, and unpreparedness in solving problems without explicit instructions.

B. Discussion

Based on the analysis of six subjects, students' mathematical problem-solving abilities were categorized into three levels: high, moderate, and low. In the first problem, T1 and T2 showed good performance, although T1 made a calculation error. S1 and S2, as moderate-category students, also demonstrated fairly good initial abilities, with S1 completing the explore and plan through find an answer stages, though less optimal in understanding the problem and reflection. S2, meanwhile, had not yet performed well in the explore and plan stage. In the low category, R1 performed relatively well in the explore and plan and find an answer stages, while R2 met all indicators optimally.

In the second problem, T1 and T2 continued to apply appropriate strategies and produced correct solutions, although T2 showed a slight decline, particularly in reading the problem and reflecting. In the moderate category, S1 began to show a decrease, especially in the explore and plan indicator, which was not achieved. S2 also began to struggle, particularly in selecting strategies, solving the problem, and reflecting. In the

low category, R1 performed better than R2 in the second problem. R1 achieved well in strategy, solving, and reflection, although their understanding still needed improvement. Meanwhile, R2 only showed strength in the initial stage of understanding the problem but declined in the following stages, resulting in a less optimal outcome.

In the third problem, high-category students continued to apply suitable strategies and produce accurate solutions, although T2 showed decreased performance in the first and second indicators. S1, in the moderate category, experienced a decline, especially in the explore and plan stage. S2 showed significant difficulties from explore and plan to reflect and extend, with most indicators minimally achieved. Low-category students experienced the most significant decline. R2 was unable to solve the problem at all due to lack of attempt. R1, on the other hand, still showed limited achievement in several stages, although the result was not optimal.

A math problem becomes a problem for students when it is non-routine, unfamiliar, and cannot be solved directly (Faza et al., 2022). According to Schukajlow et al. (2023), students who worked on problems with specific guidance showed higher success rates and were more likely to include numerical assumptions than those without guidance. Krulik and Rudnick proposed five interrelated problem-solving steps: read and think, explore and plan, select a strategy, find an answer, *and* reflect and extend (Lukman et al., 2023). Students' low performance is often caused by a lack of experience in solving problem-based questions (Reva et al., 2025), and errors in one stage can affect performance in others (Sari et al., 2020). Therefore, students' varying abilities in solving contextual circle problems can be analyzed based on their successes or difficulties in carrying out these five stages.

CONCLUSION

The results of the study show that students' mathematical problem-solving abilities in solving contextual circle problems varied across each question. In the first problem, most students from all categories were able to solve the problem according to the indicators, although there were still some errors in certain stages such as calculation and reflection. In the second problem, one student in the moderate category showed a decline from the planning to reflection stages, resulting in a less optimal outcome. Students in the low category showed a more significant decline and were not yet able to solve the problem effectively. In the third problem, only students in the high category consistently demonstrated strong abilities, while those in the moderate and low categories experienced

difficulties in nearly all stages. One student in the low category did not show any attempt to solve the problem. Thus, students' profiles of mathematical problem-solving abilities are reflected through their performance across the five stages, and these findings can be used by teachers to design structured learning activities and worksheets based on the Krulik and Rudnick model.

REFERENCES

Alsina, Á., Pincheira, N., & Delgado-Rebolledo, R. (2024). The professional practice of designing tasks: how do pre-service early childhood teachers promote mathematical processes in early algebra? *ZDM - Mathematics Education*, *56*(6), 1197–1210. https://doi.org/10.1007/s11858-024-01636-1

Amalina, I. K., & Vidákovich, T. (2023a). Cognitive and socioeconomic factors that influence the mathematical problem-solving skills of students. *Heliyon*, *9*(9). https://doi.org/10.1016/j.heliyon.2023.e19539

Amalina, I. K., & Vidákovich, T. (2023b). Development and differences in mathematical problem-solving skills: A cross-sectional study of differences in demographic backgrounds. *Heliyon*, *9*(5). https://doi.org/10.1016/j.heliyon.2023.e16366

Arifin, S., Zulkardi, Putri, R. I. I., Hartono, Y., & Susanti, E. (2020). Scaffolding in mathematical problem-solving. *Journal of Physics: Conference Series*, *1480*(1). https://doi.org/10.1088/1742-6596/1480/1/012054

Chavarría-Arroyo, G., & Albanese, V. (2023). Contextualized Mathematical Problems: Perspective of Teachers about Problem Posing. *Education Sciences*, *13*(1). https://doi.org/10.3390/educsci13010006

Csapó, B., & Molnár, G. (2017). Potential for assessing dynamic problem-solving at the beginning of higher education studies. *Frontiers in Psychology*, *8*. https://doi.org/10.3389/fpsyg.2017.02022

Faza, M. R., Regeta, N. R., & Nurilah, R. C. F. (2022). Analisis Kemampuan Pemecahan Masalah Matematis Siswa SMK dengan Metode 3D pada Materi Barisan dan Deret. *Prosiding Seminar Nasional Pendidikan Matematika IV (Sandika IV*, *4*(Sandika IV), 81–90.

Isfahani, M. M. H., Zuhriawan, M. Q., & Ashoumi, H. (2024). Krulik and Rudnick ' s Perspective : Analysis of Reflective Thinking Ability of Students. *SCHOOLAR:Social and Literature Study in Education*, *4*(2), 101–108. https://doi.org/ttps://doi.org/10.32764/schoolar.v4i2.4950

Lomibao, L. S., Silk, C. J. G., & Luna, C. A. (2017). Contextualized Problem Solving: It's Effect on Students' Achievement, Conceptual Understanding and Mathematics Anxiety. *International Journal of Science and Research (IJSR)*, *6*(7), 2188–2198. https://doi.org/10.21275/art20175656

Lukman, H. S., Setiani, A., & Agustiani, N. (2023). Pengembangan Instrumen Tes Kemampuan Pemecahan Masalah Matematis Berdasarkan Teori Krulik dan Rudnick: Analisis Validitas Konten. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *7*(1), 326–339. https://doi.org/https://doi.org/10.31004/cendekia.v7i1.1761

Mustaghisa, A., & Chandra, T. D. (2024). Analisis Kesalahan Siswa Berdasarkan Teori Newman dalam Menyelesaikan Soal Cerita Materi Lingkaran. *Jurnal Riset HOTS Pendidikan Matematika*, *4*(3), 1122–1145. https://doi.org/https://doi.org/10.51574/kognitif.v4i3.2025

OECD. (2023). *PISA 2022 Results (volume I and II) - Country Notes: Phipilippines* (pp. 1–10). https://oecdch.art/a40de1dbaf/C266.

Rayhan, N. C., & Juandi, D. (2023). Students Learning Obstacles Related to Mathematical Literacy Problem: A Systematic Literature Review. *Mathline : Jurnal Matematika Dan Pendidikan Matematika*, *8*(2), 457–472. https://doi.org/http://doi.org/10.31943/mathline.v8i2.411

Rayhan, N. C., Suryadi, D., & Hasanah, A. (2025). Investigating Learning Obstacles In Mathematical Literacy: A Study On Linear Equations With One Variable. *Mathline : Jurnal Matematika Dan Pendidikan Matematika*, *10*(1), 193–207. https://doi.org/http://doi.org/10.31943/mathline.v10i1.825

Reva, A., Aulia, R., Setyarini, M., Karimah, S., & Hidayah, N. (2025). Analisis Kemampuan Pemecahan Masalah Matematis Siswa SMP Pada Materi SPLDV Melalui Pendekatan Krulik dan Rudnick. *Prosiding Seminar Nasional Pendidikan Matematika VI*, *6*(3), 333–342.

Safrudin, R., Zulfamanna, Kustati, M., & Sepriyanti, N. (2023). Penelitian Kualitatif. *INNOVATIVE: Journal Of Social Science Research*, *3*(2), 1–15. https://j-innovative.org/index.php/Innovative/article/view/1536

Sari, D. S. M., Fatih 'Adna, S., & Mardhiyana, D. (2020). Analisis kemampuan pemecahan masalah siswa berdasarkan teori wankat dan oreovocz. *Jurnal Pendidikan Matematika Undiksha*, *11*(2), 15–25.

Schukajlow, S., Krawitz, J., Kanefke, J., Blum, W., & Rakoczy, K. (2023). Open modelling problems: cognitive barriers and instructional prompts. *Educational Studies in Mathematics*, *114*(3), 417–438. https://doi.org/10.1007/s10649-023-10265-6

Sensus, M., Arifin, K., & Munir, A. (2022). Validitas Soal pada Asesmen Kompetensi Minimum Materi Ekologi SMA Kelas X. *Wahana-Bio: Jurnal Biologi Dan Pembelajarannya*, *14*(1), 1–10. https://doi.org/10.20527/wb.v14i1.14013

Sesa, S. A., Tanujaya, B., & Firmansyah, F. (2022). Analisis Kemampuan Pemecahan Masalah Matematika Siswa Smp Berdasarkan Kriteria Krulik Dan Rudnick. *Jurnal Theorems (The Original Research of Mathematics)*, *6*(2), 85. https://doi.org/10.31949/th.v6i2.3466

Sholihah, E. P., Sugiyanti, S., Rasiman, R., & Astuti, D. (2024). Analisis Kemampuan Pemecahan Masalah Matematis Siswa SMA Kelas XI Pada Materi Lingkaran. *FARABI: Jurnal Matematika Dan Pendidikan Matematika*, *7*(1), 59–67. https://doi.org/https://doi.org/10.47662/farabi.v7i1.720

Siswanto, R. D., & Ratiningsih, R. P. (2020). Korelasi Kemampuan Berpikir Kritis dan Kreatif Matematis dengan Kemampuan Pemecahan Masalah Matematis Materi Bangun Ruang. *ANARGYA: Jurnal Ilmiah Pendidikan Matematika*, *3*(2), 96–103. https://doi.org/https://doi.org/10.24176/anargya.v3i2.5197

Suryaningsih, T. (2019). Hard Work and Problem Solving Based on Krulik-Rudnick's Heuristic Theory on Project Based Learning with OQALE Approach Of 5th Grade Elementary School Students. *JMIE: Journal of Madrasah Ibtidaiyah Education*, *3*(1), 91–99. https://doi.org/http://dx.doi.org/ 10.32934/jmie.v3i1.101

Tohir, M., Susanto, Hobri, Suharto, & Dafik. (2018). Students' Creative Thinking Skills in Solving Mathematics Olympiad Problems Based on Problem-Solving Polya and Krulik-Rudnick Model. *Advanced Science Letters*, *24*(11), 8361–8364. https://doi.org/10.1166/asl.2018.12563

Utami, W. B., Widodo, S. A., & Sulistyowati, F. (2022). *Matematika Tingkat Lanjut* (L. Aditya (ed.)). Pusat Perbukuan Badan Standar, Kurikulum, dan Asesmen Pendidikan Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi.

Vessonen, T., Hellstrand, H., Kurkela, M., Aunio, P., & Laine, A. (2025). The effectiveness of mathematical word problem-solving interventions among elementary schoolers: A systematic review and meta-analysis. *International Journal of Educational Research, 132*(May), 102642. https://doi.org/10.1016/j.ijer.2025.102642

Waruwu, M. (2023). Pendekatan Penelitian Pendidikan: Metode Penelitian Kualitatif, Metode Penelitian Kuantitatif dan Metode Penelitian Kombinasi (Mixed Method). *Jurnal Pendidikan Tambusai*, *7*(1), 2896–2910. https://doi.org/10.31004/jptam.v7i1.6187

Zulfirman, R. (2022). Implementasi Metode Outdoor Learning dalam Peningkatan Hasil Belajar Siswa pada Mata Pelajaran Agama Islam di MAN 1 Medan. *Jurnal Penelitian, Pendidikan Dan Pengajaran: JPPP*, *3*(2), 147–153. https://doi.org/10.30596/jppp.v3i2.11758