Edumatica: Jurnal Pendidikan Matematika
Volume 13 Number 03 December 2023

Submited : 09 December 2022
Revised : 30 November 2023
Accepted : 13 December 2023

Kemampuan Pemecahan Masalah Geometri Siswa berdasarkan Self-Regulated Learning

Rif'atul Syarifah[1], Hendro Permadi[2], Abdul Qohar[3], Lathiful Anwar[4]
[1,2,3,4]Mathematics Education, State University of Malang, Indonesia
E-mail: *ri.fatulsy@gmail.com[1], abd.qohar.fmipa@um.ac.id* [2]

Abstrak

Geometri merupakan salah satu pokok bahasan dalam matematika yang dapat mengukur kemampuan pemecahan masalah, karena geometri membahas tentang benda-benda, definisi, simbol dan gambar yang dapat digunakan sebagai ide atau gagasan oleh siswa. Penelitian ini adalah penelitian kualitatif deskriptif yang bertujuan untuk mendeskripsikan dan menganalisis kemampuan siswa dalam pemecahan masalah berdasarkan langkah-langkah Polya ditinjau dari *Self-Regulated Learning* (SRL). Subjek dari penelitian ini adalah satu siswa di setiap tingkat SRL (tinggi, sedang, rendah). Metode pengumpulan data yaitu berupa angket, tes dan wawancara. Hasil penelitian menunjukkan bahwa 12.5% siswa memiliki tingkat SRL tinggi, 70.83% siswa memiliki tingkat SRL menengah dan 16.67% siswa memiliki tingkat SRL rendah. Siswa dengan SRL tinggi dapat melakukan pemecahan masalah sesuai langkah-langkah Polya dengan lengkap. Siswa dengan SRL sedang dapat menerapkan langkah memahami masalah (menulis informasi dan apa tujuan masalah) dan langkah perencanaan. Sementara itu, siswa dengan SRL rendah dapat memahami masalah pada soal. Berdasarkan wawancara siswa hanya bisa memberikan informasi dari yang terdapat pada soal namun tidak memiliki ide untuk menyelesaikannya. Siswa dengan SRL rendah hanya mampu melakukan tahapan pertama dari empat tahapan pemecahan masalah. Sehingga hasil penelitian ini dapat disimpulkan bahwa semakin tinggi SRL atau tingkat kemandirian belajar seseorang, maka akan semakin tinggi pula kemampuan pemecahan masalahnya.

Kata Kunci: kemandirian belajar, pemecahan masalah, transformasi geometri

Students' Problem Solving Abilities of Geometry Transformation Based on Self-Regulated Learning

Abstract

One of the subjects that can measure students' problem solving abilities is geometry because geometry discusses objects, definitions, symbols and images that can be used as ideas or ideas by students. This research is a descriptive qualitative study which aims to describe and analyze students' ability to solve problems based on Polya's steps in terms of self-regulated learning (SRL). The subject of this research is one student in each SRL (high, medium, low). Data collection methods are questionnaires, tests and interviews. The results showed that 12.5% of students had high SRL levels, 70.83% had medium SRL level students and 16.67% had low SRL level students. Students with high SRL can complete problem solving according to Polya's steps. Students with moderate SRL can apply the steps of understanding the problem (writing the information available and what is being asked) and the planning steps. Meanwhile, students with low SRL can understand the problems in the questions. Based on interviews students can only provide information from what is contained in the questions but do not have ideas to solve them. Students with low SRL are only able to do the first of the four stages of problem solving. So, it can be concluded that the higher the SRL or the level of one's learning independence, the higher the ability to solve problems.

***Keywords**: geometry transformation; problem solving; self-regulated learning*

INTRODUCTION

Mathematics is one of the fields of knowledge that plays a crucial role in various aspects, ranging from everyday life to the development of science and technology. The greater the role of mathematics, the higher the demand for mathematical abilities that must be possessed. Besides arithmetic skills, mathematical abilities also encompass logical and critical reasoning skills in problem-solving (Fathani, 2016). Problem-solving ability is one of the competencies in mathematics learning that students must possess. This is reinforced by the inclusion of problem-solving ability as part of the curriculum based on STEM (Bears et al., 2017). Problem-solving in the learning process is an approach that describes learning beginning with the presentation of contextual problems, followed by inductive reasoning, and students rediscovering the concepts they have learned (Hendriana & Soemarmo, 2014). In mathematics learning, one of the fundamental skills that students must have been problem-solving ability. Therefore, mathematical problem-solving skills play a crucial role in achieving the goals of mathematics education in schools, providing students with tools not only during the learning process but also in everyday problem-solving situations (Mahfuddin & Caswita, 2021).

The indicators of problem-solving are as follows: (1) identifying the known and unknown elements, as well as the sufficiency of the required elements, (2) formulating mathematical problems or constructing mathematical models, (3) applying strategies to solve the problems, (4) explaining or interpreting the results of problem-solving (Hendriana & Soemarmo, 2014). These indicators align with the four stages of problem-solving according to Polya; (1) understanding the problem, (2) devising a plan to solve the problem, (3) executing the plan, (4) checking back (Polya, 1973). One of the essential problem-solving activities in mathematics learning is word problems (Saputri, 2019). Word problems are commonly used to assess students' mathematical problem-solving abilities (Machmurotun, 2014). Word problems are mathematical questions expressed or presented in words or sentences that are easily understood, in the form of stories related to daily life (Wahyuddin, 2016). The purpose of using word problems in mathematics is to help student's practice deductive thinking, see the relevance and usefulness of mathematics in daily life, and master mathematical skills and concepts (Dewi et al., 2014). Therefore, solving mathematical word problems is not just about getting the answers; more importantly, students should know and understand the necessary steps to obtain the solution.

One of the mathematical subjects that has been taught from the basic level is geometry. Geometry is a field of mathematical knowledge that studies points, lines, planes, and space, as well as their properties, measurements, and interrelations (Nur'aini et al., 2017). According to the NCTM, geometry is also one of the essential domains included in the five content standards of mathematics, namely; (1) number and operations, (2) algebra, (3) geometry, (4) measurement, (5) data analysis and probability (NCTM, 2000). One branch of geometry is geometric transformations. Geometric transformations involve changing the position or location of a point in Cartesian coordinates according to certain rules. There are four types of transformations: translation, reflection, rotation, and dilation (Listiawan & Antoni, 2021). Furthermore, geometric transformations play a significant role in students' development, such as building spatial abilities, geometric reasoning skills, and strengthening mathematical proofs (Albab et al., 2014). Therefore, by studying geometry, students can enhance their character and mathematical abilities, including problem-solving skills.

Problem-solving is an effective concept for understanding things related to contexts, for operational and foundational transfer of mathematical knowledge, and for ensuring continuous and meaningful learning (Căprioară, 2015). An individual's problem-solving ability is also influenced by their self-regulated learning (SRL) strategies. Factors that influence a person's problem-solving ability include their personal habits, individual situations, stress, and frustration (Kluytmans, 2006). Self-regulated learning (SRL) refers to the ability of students to control themselves in learning, commonly known as students' self-directed learning (Zamnah, 2019). Self-regulation on behalf of the student is crucial in learning Mathematics (Cueli et al., 2017). In essence, self-regulated learning emphasizes an individual's ability to organize and control oneself, for example, when facing academic tasks. SRL is aimed at improving academic performance, and problem-solving is one of the academic self-regulatory processes in learning. SRL efforts lead students to engage in learning processes to achieve suitable outcomes, particularly in mathematics, where students can achieve success in this subject. Factors influencing self-directed learning include psychological factors (motivation), intelligence, and prior learning interests of students; physiological factors (health conditions and physical disabilities of students); and environmental factors (family support, surrounding environment, and school atmosphere) (Handayani & Ariyanti, 2021). Additionally, an individual's desire for autonomy arises from internal factors, such as the realization of experiences and a process towards self-improvement (Suid et al., 2017). However, students' initiative to engage in independent learning activities during the mathematics learning process is limited (Kurnia & Warmi, 2019).

Research on problem-solving ability and self-regulated learning has been conducted by several researchers before, including a study by Handayani and Ariyanti titled "Self-Directed Learning of Mathematics for Junior High School Students during the Covid-19 Pandemic." This research observed the self-directed learning of junior high school students. The study produced data on the level of students' self-directed learning during the pandemic without considering other factors that could be observed from their self-directed learning. Another study was conducted by Căprioară with the research title "Problem Solving – Purpose and Meaning of Learning Mathematics in School." This research outlined the difficulties students faced in solving mathematical problems and how to teach students to solve mathematical problems. It also mentioned that students' problem-solving abilities can be enhanced not only through classroom learning but also through self-directed learning for even better problem-solving abilities. However, further research is needed to investigate the influence of self-directed learning on students' problem-solving abilities. Continuing with research by Rahayuningsih et al. titled "The Effect of Self-Regulated Learning on Students' Problem-Solving Abilities." This study, however, concluded that self-regulated learning does not have a significant effect on students' problem-solving abilities. However, in other studies, it has been elucidated that self-regulated learning can indirectly enhance the accuracy of mathematical problem-solving by utilizing working memory during the execution of self-directed learning (Ferreira et al., 2022). The success of learning can be assessed through students' achievements in problem-solving and self-regulation regarding task-related activities by orienting themselves towards the tasks (Corte, 2016). This is supported by the assertion that problem-based learning can assist students in achieving success in their educational endeavors (Bailey, 2022). Therefore, it is imperative to conduct research on the correlation between students' problem-solving abilities in resolving mathematical problems and the level of self-regulated learning.

In the recent mathematics learning outcomes at one of the secondary schools in Pamekasan Regency, it is suspected that mathematics learning in one of the secondary schools in Pamekasan Regency is not very effective in helping students solve mathematical problems related to geometric transformations. The difficulties experienced are related to the adjustment of the learning situation post-pandemic and the knowledge students acquired during the pandemic learning period. Interviews with one of the teachers at the school also revealed that most students cannot engage in self-directed learning to supplement their understanding of the subject matter. As a result, many students have low learning outcomes, especially in problem-solving abilities. It can be assumed that these issues are related to students' self-directed learning abilities.

Regarding these issues, the aim of this research is to analyze and describe how problem-solving ability is dependent on how students self-regulate themselves to achieve success. Therefore, research is needed to investigate problem-solving abilities in geometric transformations based on the level of self-regulated learning (SRL).

METHOD

This research is a qualitative descriptive study. The purpose of this research is to describe the problem-solving steps based on Polya's method, observed from the level of students' self-regulated learning (SRL). Data collection techniques include tests, interviews, and questionnaires. The research was conducted at MAN 1 Pamekasan during the academic year 2022/2023. The selection of research subjects was based on purposive sampling technique.

The first SRL instrument consisted of problem-solving test questions conducted by the selected subjects. The results of the problem-solving test were then evaluated based on the criteria for problem-

 Print ISSN: 2088-2157, Online ISSN: 2580-0779

solving ability according to Polya. In addition to the test questions, there were several questions as interview instruments used to support the data obtained after the problem-solving test.

Furthermore, the instrument used was a Likert questionnaire to categorize high, moderate, and low levels of SRL. The self-regulated learning scale questionnaire was developed based on learning indicators measured from respondents' abilities to respond to the self-regulated learning scale. The self-regulated learning scale questionnaire was developed based on the following indicators: (1) learning initiative, (2) diagnosing learning needs, (3) setting learning goals, (4) monitoring, organizing, and controlling learning, (5) viewing difficulties as challenges, (6) utilizing and seeking relevant sources, (7) choosing and determining appropriate learning strategies, (8) evaluating the process and learning outcomes, (9) self-concept (Zamnah, 2019).

The Likert scale in the assessment of mathematical self-regulated learning consists of positive and negative statements using five options: SS (strongly disagree), S (disagree), N (neutral), A (agree), and SA (strongly agree). Students' responses to positive statements are given scores of SS = 1, S = 2, N = 3, A = 4, and SA = 5. Meanwhile, students' responses to negative statements are given scores of SS = 5, S = 4, N = 3, A = 2, SA = 1.

The calculation formula used for the percentage of respondents is:

$$s = \frac{f}{n} \times 100 \ldots \ldots (1)$$

Information
s = SRL Score
f = The frequency being searched for
n = The total number of frequencies

Furthermore, the percentage value obtained is entered into the standard object criteria as follows:

Table 1. Standar Kualifikasi SRL

High	$p \geq \bar{x} + SD$
Medium	$\bar{x} + SD > p > \bar{x} - SD$
Low	$p \leq \bar{x} - SD$

(Rachmawati et al., 2021)

Information
$\bar{x}$: Score average of SRL
SD : Standard deviation
s : SRL Score

The test instrument in the form of problem solving ability consists of one item. From each category of independent learning, one subject was taken to carry out a problem-solving test based on students' communication skills and teacher recommendations. Data analysis technique is data reduction, presentation of data, drawing conclusions and verification. Data validity was carried out using the triangulation method. The triangulation method is to compare data from written (test) to oral (interview). If the triangulation data is the same, then the subject data is valid.

RESULTS

The research subjects were students of class XI IPA-1 MAN 1 Pamekasan. Of the 24 students of class XI IPA, in the first stage, using a self-regulated learning questionnaire and data from self-regulated learning or independent learning of students in this study will be presented in Table 2.

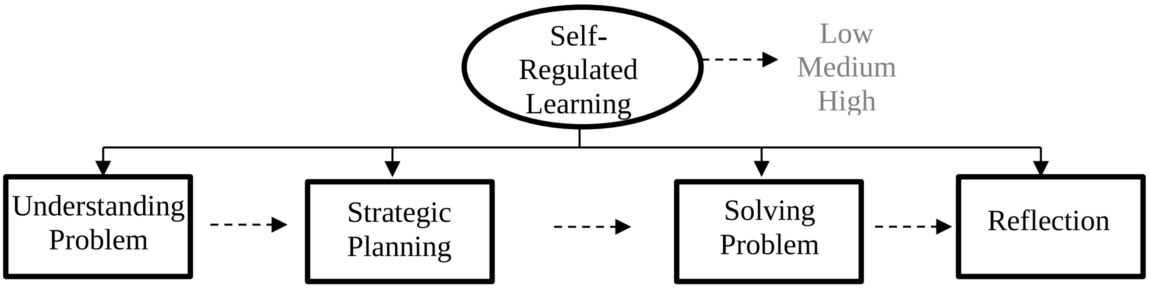
Table 2. Student self-regulated learning questionnaire results

High	3 students
Medium	17 students
Low	4 students

Based on Table 2, it was found that 3 students got high SRL, 17 students got medium SRL and 4 students got low SRL. The number of subjects in this study was 1 student from each SRL category, so there were 3 subjects in total. These subjects were Subject 1 (S1) with a score of 82.14 on the self-regulated learning questionnaire test, Subject 2 (S2) with 62.86 on the self-regulated learning questionnaire test, and Subject 3 (S3) with a score of 46.43 on the self-regulated questionnaire test regulated learning. Then the three subjects were given tests in the form of problem solving questions and interviews regarding test results. The test instrument used consisted of one question, namely:

> "Andi is playing ball with his friends, the ball's position is right at Andi's feet where the ball's position is 4 steps to the east then 2 steps to the south from the middle of the field. If the middle of the field represents the center point (0,0) and Andi kicks the ball west 2 steps then north 5 steps, then the ball's position after being kicked is… (Write in full the stages of completion and state the ball's position in coordinates)"

The following describes the problem-solving abilities of selected students in terms of each indicator after conducting problem-solving tests and interviews on the subject:



Subject 1 obtained a score of 82.14/100 on the self-regulated learning test, so that subject 1 (S1) was categorized as a student with a high level of self-regulated learning.

Indicator 1 (Understand the Problem)

At this step students are required to be able to write down what is known and asked about the problem, make an overview of the information on the problem if possible, or try to understand both simple and specific problems.

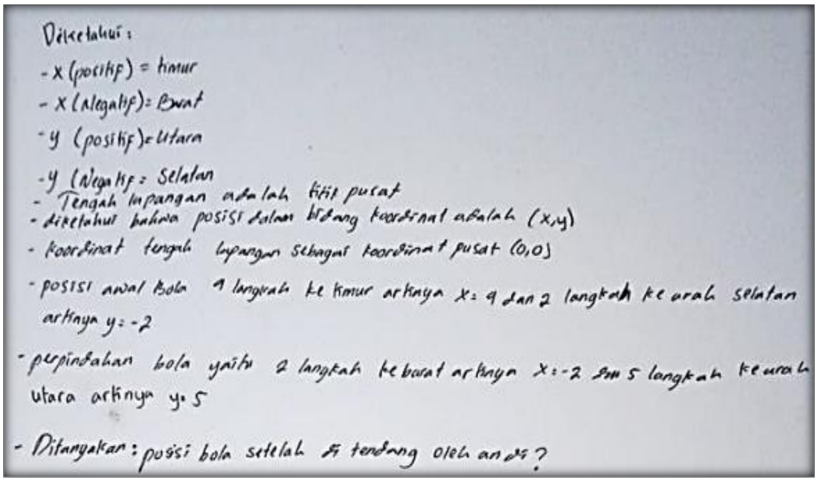


Figure 1 Results of Understanding the Problem by S1

Based on the results of the problem-solving ability test instrument shown in Figure 1, the fact is that the data from the questions are in the form of things that are known and asked, students can write them down in full. This can be observed from how students take the cardinal directions as the direction of the coordinate plane, write down the position of the center of the field, and write instructions for the initial position of the ball and the direction of its movement. During the interview students can explain the problem in a language that students understand.

P : "What kind of information did you get from the question?"

S1 : "The position of the ball is at Andi's feet, which is 4 steps to the east and then 2 steps to the south. Furthermore, information about the center of the field, namely (0,0) and the displacement of the ball when kicked by Andi, is 2 steps to the west and 5 steps to the north"

Indicator 2 (Planning to Solve)

In this step, students plan and design what planning solutions will be carried out both systematically and rationally, how to implement them, and what results are expected.

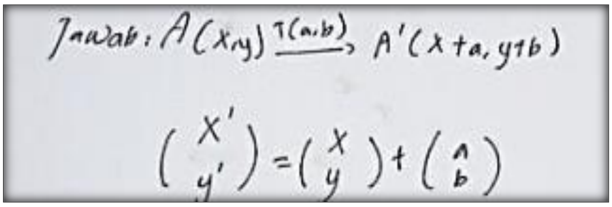


Figure 2 Results of Plan Completion to Solve by S1

In Figure 2, students write alternative solutions in the form of writing the general translation formula. This was confirmed by several interview questions, along with the student's answers during the interview:

P : "What is your plan to solve this problem?"

S1 : "The question from the test is the position of the ball after moving, so I use the translation formula to solve it"

P : "What about displacement expressed in terms of direction?"

S1 : "I've already exemplified it in the coordinate plane"

Indicator 3 (Solving Problems)

In this step, students finding a solutions to the first problem. Solutions are sought using the previously stated plans.

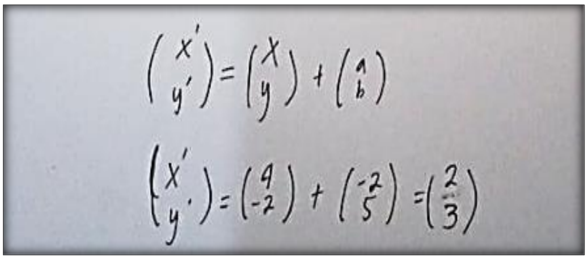


Figure 3 Completion Results by S1

As seen in Figure 3, it can be assumed that S1 has been able to complete the plan and calculate the position of the ball after being kicked. The following are students' answers to the questions asked regarding related test results:

P : "How do you get the initial position of the ball?"

S1 : "In the ball position problem 4 steps to the east i.e. x is positive and then 2 steps to the south i.e. y is negative meaning $(4, -2)$.

P : "Then for the large displacement?"

S1 : "The magnitude of the displacement caused by Andi kicking 2 steps to the west and 5 steps to the north means $(-2,5)$. After being substituted into the translation formula $(4, -2) + (-2,5) = (2,3)$.

Indicator 4 (Re-examination/Look back and Reflect)

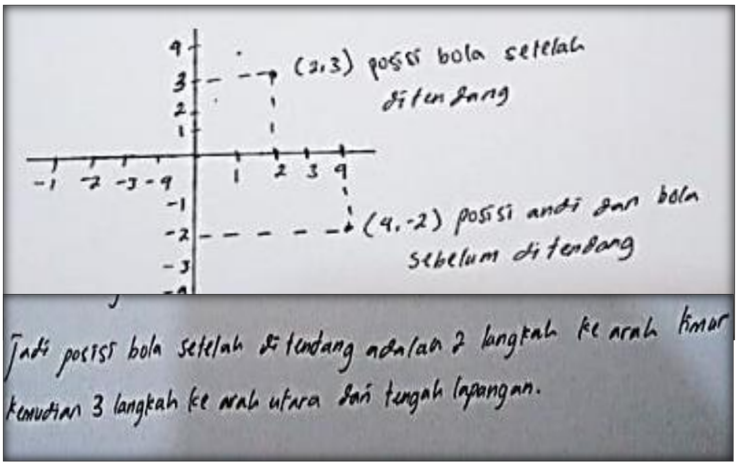


Figure 4 Re-examination Results and Conclusions by S1

In Figure 4, S1 solves the problem by drawing it on the coordinate plane, besides that S1 writes the conclusions from the answers to the problems so that it can be assumed that S1 is able to complete the re-examination stage. The following are the results of the S1 interview regarding test results:

P : "Are you sure your answer is correct?"

S1 : "Sure, because actually I described the problem in the coordinate plane and then I checked again with the translation formula that was given"

P : "Does your answer solve the first problem?"

S1 : "Yes, because I can answer where the ball is after being kicked"

P : "What difficulties did you face in solving the problem?"

S1 : "At first it was a little difficult to state the direction in the coordinate plane, but I read the problem over and over again".

Subject 2 obtained a score of 62.86/100 on the self-regulated learning test, so that subject 2 (S2) was categorized as a student with a moderate level of self-regulated learning.

Indicator 1 (Understand the Problem)

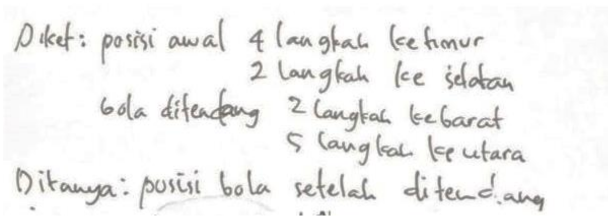


Figure 5 Results of Understanding the Problem by S2

It can be seen in Figure 5, that the data from the questions are in the form of things that are known and asked that students can write down, namely in the form of the starting position, the direction of the ball kick, and the purpose of the question. During the interview the S2 can explain the problem in a language that students understand, namely as follows:

P : "What kind of information did you get from the question?"

S2 : "The initial position of the ball at Andi's feet is 4 steps east and then 2 steps south from the middle of the field. The movement of the ball when kicked by Andi is 2 steps to the west and 5 steps to the north"

P : "What about displacement expressed in terms of direction?"

S2 : "I… still a little doubtful in interpreting it" (Students answered doubtfully)

Print ISSN: 2088-2157, Online ISSN: 2580-0779

Indicator 2 (Planning to Solve)

In Figure 6, students write alternative solutions in the form of writing translation formulas so that

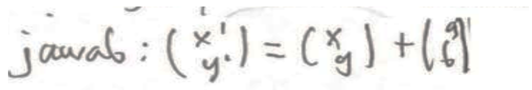


Figure 6 Results of Plan Completion to Solve by S2

students can be assumed to be able to plan solutions to produce the goals of the problem. When interviewed students can explain as follows:

P : "What is your plan to solve this problem?"

S2 : "Because what is asked is the position of the ball after moving, so I use the translation formula to solve it"

P : "Do you understand the meaning of the formula you have written?"

S2 : "Yes I understand. x' and y' is the position of the ball after moving, whereas x and y is the initial position of the ball, a and b is the displacement magnitude."

Indicator 3 (Solving Problems)

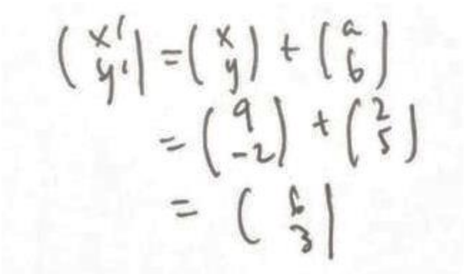


Figure 7 Completion Results by S2

In Figure 7, it can be seen that S2 completed the questions according to the plan carried out in the previous stage. This was confirmed by the following interview questions:

P : "How do you get the initial position of the ball?"

S2 : "The position of the ball is 4 steps to the east which is x positive and then 2 steps to the south which is y negative from the middle of the court meaning$(4, -2)$.

P : "if in the initial position of the ball you said that to the east it is x positive, then what about the displacement to the west is x positive?

S2 : "…" (Student is confused without answering)

Indicator 4 (Re-examination/Look back and Reflect)

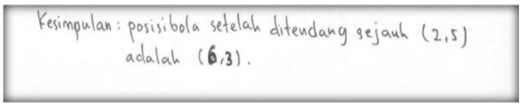


Figure 8 Re-examination Results and Conclusions by S2

As seen in Figure 8, S2 did not re-check the answer. But S2 provides a conclusion to the answer. In conclusion "the position of the ball after being kicked so far $(2,5)$ is $(6,3)$"

P : "Are you sure your answer is correct?"

S2 : "…not sure" (The student thought for a moment then answered doubtfully)

P : "What do you think is not right?"

S2 : "In the determination of positive and negative in numbers"

P : "Have you checked your answer again?"

S2 : "I just re-read before collecting"

Subject 3 obtained a score of 46.4/100 on the self-regulated learning test, so that subject 3 (S3) was categorized as a student with a low level of learning independence.

Indicator 1 (Understand the Problem)

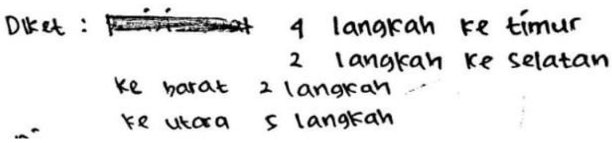


Figure 5 Results of Understanding the Problem by S3

It can be seen that S3 can briefly write down what is known but does not write down what is asked. The following is a confirmation interview with students:

P : "What kind of information did you get from the question?"
S3 : "The initial position of the ball is 4 steps east and 2 steps south from the center of the court. Andi kicks the ball 2 steps to the west and 5 steps to the north"
P : "What do you mean by position 4 steps east 2 steps south and west 2 steps north 5 steps in the answer sheet?"
S3 : "That was the initial position of the ball and the direction in which Andi kicked the ball, I don't give much information"
P : "What about displacement expressed in terms of direction?"
S3 : "I… it looks like it should be changed but I have no idea"
P : "Do you know what to look for in solving the problem?"
S3 : "The position of the ball after being kicked"

Indicator 2 (Planning to Solve)

In this step, students plan and design what kind of solution will be carried out both systematically and rationally, how to implement it, and what results are expected. However, S3 did not write anything down at this stage, so this was confirmed by the following interview:

P : "What is your plan to solve this problem?"
S3 : "…" (Students do not answer)
P : "Do you have any ideas to solve this problem?"
S3 : "There is… (Pause) using the geometric transformation formula"
P : "What kind of geometric transformation do you mean? Rotating or mirroring or displacement or resizing?"
S3 : "Displacement"
P : "Why displacement (move)? What is the displacement term called in the geometric transformation?"
S3 : "Because Andi kicked the ball, the ball moved. It's called translation"
P : "what terms usually the position in translation uses?"
S3 : "The x and y terms in the coordinate plane"
P : "Does the problem have a position in coordinates?"
S3 : "Nothing and I don't know how to change the "direction" into position in coordinates"

Unfortunately, S3's interview must be cut in the second stage because S3 has no more something to write and explain. In conclusion, S3 cannot solve the problem and doesn't understand it well.

DISCUSSION

3.1 Problem Solving Ability of Students with High SRL

The stage of understanding the problem has been carried out by the students. They obtained information from the problem and understood its objective. The students illustrated the problem by providing additional information not present in the given question, for example, by mapping the cardinal

 Print ISSN: 2088-2157, Online ISSN: 2580-0779

directions to the Cartesian coordinate plane. In addition to the test results, during the interviews, the students were able to explain well. Based on the aforementioned information, it can be observed that students with a high level of SRL can comprehend the problem well and understand its objective. This aligns with the views of previous researchers, stating that students with high SRL can organize and understand their learning goals and desired achievements (Granberg et al., 2021). Another perspective on this matter is that "students with high SRL can find and connect their prior knowledge with the problem to be solved" (Yaniawati et al., 2019).

Based on Figure 2 and the consistency with S1's interview response, it appears that S1 can accurately explain the planning stage that will be undertaken. This indicates that the student can utilize prior knowledge as a bridge to solve the presented problem. This aligns with the findings of previous researchers, stating that students with a high level of SRL can discover connections between prior knowledge and the problem to be solved (Yaniawati et al., 2019). Another researcher's perspective is that students with a high level of SRL can identify desired achievements and determine appropriate ways to achieve those (Granberg et al., 2021). Therefore, based on the observations made on S1 and the support from the findings of previous researchers, it can be concluded that students with a high level of SRL can successfully complete the second stage in the problem-solving process.

The interview results in third stage, S1 was able to explain what was written accurately, meaning that S1 could complete the solution plan and calculate the position of the ball after being kicked correctly. S1, with a high level of SRL, could solve the problem accurately using the formulas previously written in the second stage. This is consistent with previous findings that there is a significant relationship between SRL level and mathematical problem-solving ability, and students with high SRL can solve problems (Sundayana, 2018). Another perspective on this matter is that "students with high SRL can utilize their prior knowledge to solve problem-solving questions" (Yaniawati et al., 2019). According to analysis results, reinforced by interviews with the students, it was found that S1 with a high level of self-regulated learning (SRL) is capable of understanding the objective of the given problem. This is evident from how the student wrote down what is known and what is asked in Figure 1. This is consistent with previous findings that "students who have the information to solve the problem, meaning they understand the purpose of the problem-solving" (Udil et al., 2017).

Furthermore, S1 can find ways or strategies to solve the problem. This is evident in how S1 plans to solve the problem by using relevant mathematical formulas or concepts. S1 analyzes what is known in the problem and ultimately develops ideas, concepts, or approaches considered appropriate to solve the problem, in this case, the concept of translation, which was previously learned. In Figures 3 and 4, S1 with a high level of SRL is able to complete the problem-solving process comprehensively. Moreover, based on the interview, S1 can explain the problem-solving process effectively. This aligns with previous findings that there is a significant relationship between SRL level and mathematical problem-solving ability, and students with high SRL can solve problems with a complete problem-solving approach (Darma et al., 2016; Rachmawati et al., 2021; Sundayana, 2018). Aligned with the research findings, students with a high level of Self-Regulated Learning (SRL) tend to find it easier to resolve mathematical problems, both in theoretical and practical terms (Kramarski et al., 2010).

3.2 Problem Solving Ability of Students with Moderate SRL

The stage of understanding the problem has been carried out by the student S2 figured that S2 was able to write down the information given in the problem and the objective of the problem, it is shown in figure 5. However, S2 has not been able to illustrate the translation with directional movements on the coordinate plane. Based on the interview, the student admitted to being confused and not careful enough in solving the problem. This is in line with findings that students make errors in problem-solving because they lack attentiveness in comprehending the content of the problem and fail to understand each sentence in the question (Sudirman et al., 2018). According to previous research statements, "students with intermediate SRL can figure out the meaning of the given problem" (Bayuningsih et al., 2017). Hence, students with intermediate SRL are considered capable of completing the first stage of problem-solving.

Based on Figure 6 and S2's interview response, it is evident that S2 designed a plan to find a solution to the problem by writing down the translation formula and being able to explain its meaning effectively. Therefore, it can be said that students with intermediate SRL can comprehend and plan the problem-solving process. This aligns with the statement that "students with intermediate SRL can figure out the meaning of the given problem and can plan to solve the problem" (Bayuningsih et al., 2017). Based on the data obtained and the findings of previous researchers, it can be concluded that students with intermediate SRL can complete the second stage of problem-solving according to Polya's method.

During the interview, S2 appeared to be confused with the questions asked about their answers. The student seemed to have just realized the mistake made, which resulted in the error. This occurred in the interpretation of the sentence "The ball moves 2 steps to the west and 5 steps to the north when kicked by Andi." S2 wrote (2,5) which should be (-2,5) because the west direction corresponds to the negative x-axis direction. This is consistent with S2's acknowledgment during the interview session for the first indicator, where S2 mentioned being slightly confused about movement with directions, leading to this error. Students with intermediate SRL make mistakes in the third stage, resulting in incorrect problem-solving outcomes. This aligns with previous findings that "students make errors in problem-solving because they lack attentiveness in comprehending the content of the problem and fail to understand each sentence in the question" (Sudirman et al., 2018). Therefore, it can be said that students with low SRL can comprehend and plan the problem-solving process but are unable to execute it accurately. This is in line with the statement that "students with intermediate SRL can figure out the meaning of the given problem and can plan, but cannot implement the plan" (Bayuningsih et al., 2017).

From the data of answers and the interview with S2, it is evident that S2 lacks attentiveness in the problem-solving process, leading to an incorrect conclusion. Based on the analysis and interview results, it can be concluded that students with intermediate SRL can achieve two out of four problem-solving indicators accurately. The student is able to understand what is meant in the problem and the strategy or formula they should use to solve the problem. However, students with intermediate SRL make mistakes in the third stage, resulting in an incorrect problem-solving outcome. According to the interview, the student admitted to being confused and less attentive in solving the problem. This aligns with the finding that "students make errors in problem-solving because they lack attentiveness in comprehending the content of the problem and fail to understand each sentence in the question" (Sudirman et al., 2018).

Furthermore, in the fourth stage, students with intermediate SRL provide an incorrect conclusion. This happens because the student does not verify what they have done, so if there is an error in the third stage, it will impact the fourth stage. In solving problem-solving tests, the biggest mistake made by students is in understanding the problem and not verifying their answers (Nuryah et al., 2020). Therefore, it can be said that students with intermediate SRL can comprehend and plan the problem-solving process. This aligns with the statement that "students with intermediate SRL can figure out the meaning of the given problem and can plan, but cannot execute the third step, which is implementing the plan" (Bayuningsih et al., 2017).

3.3 Problem Solving Ability of Students with Low SRL

According to Figure 9, the test results of S3, and the interview, it appears that the student understands the problem even though the information provided on the S3 test sheet is not complete. However, during the interview, S3 was able to provide information about the details of the problem and what was being asked. Several previous studies have indicated that students with low self-regulated learning (SRL) are associated with low problem-solving abilities. This aligns with earlier research stating that "students with low SRL can only perform the stage of understanding the problem or can be considered to have limited problem-solving abilities" (Bayuningsih et al., 2017). Additionally, other research findings suggest that students with low self-regulated learning tend to only write down the explicit information present in the problem, but they struggle to comprehend the meaning or implicit information behind it (Rachmawati et al., 2021).

Based on the interview results, it appears that S3 faces difficulties in planning the problem-solving process. S3 has not mastered the material on translation and cannot convert directional units into Cartesian coordinate units. This is evident from S3's responses during the interview, where S3 could

Print ISSN: 2088-2157, Online ISSN: 2580-0779

only answer basic questions but was uncertain about their abilities. As a result, S3 did not proceed to the subsequent stages of problem-solving. Based on the analysis and interview, it can be concluded that students with low self-regulated learning (SRL) can achieve only one out of four indicators of problem-solving accurately. The student can understand the problem during the interview, although the writing is still incomplete. This aligns with previous research, which stated that "students with low SRL can only perform the stage of understanding the problem or can be considered to have limited problem-solving abilities" (Bayuningsih et al., 2017). Additionally, other research findings suggest that students with low self-regulated learning cannot solve problems correctly and precisely. They tend to only write down the explicit information present in the problem, but they struggle to comprehend the meaning or implicit information behind it (Rachmawati et al., 2021). Therefore, based on the supporting data in this study, it can be concluded that students with low SRL have limited problem-solving abilities. This can be seen from the students' performance on the problem-solving test, where they can only write down and explain the information present in the test. During the problem-planning stage, students do not provide any plans or strategies to solve the problem, thus only fulfilling the first stage of problem-solving.

Student whom can solve mathematics problem easily is student with high self-regulated learning (S1), looking back at result of subjects it shows that teacher must have a special treatment which is can up self-regulated learning per-individual. Because self-regulated learning emphasizes an individual's ability to organize and control oneself, for example, when facing academic tasks. Basically, in mathematics learning improving academic performance, and problem-solving is one of the academic self-regulatory processes in learning. Self-regulated learning efforts lead students to engage in learning processes to achieve suitable outcomes, particularly in mathematics, where students can achieve success in this subject.

CONCLUSION

From the results of the discussion above, it can be concluded that students with high SRL can carry out all the Polya problem solving steps well, namely understanding the problem, planning problem solving, implementing the settlement plan and evaluating it. Students with moderate SRL are able to work on problem understanding stage questions. In the planning step, students write strategies toward answers. The implementation stage carries out the planned strategy, seeks a solution using the formula or strategy that has been written but the results are not quite right. At the evaluation stage, the conclusions and results obtained were inaccurate, this was due to the wrong displacement substitution, so that students with moderate SRL were only able to carry out two of the four problem solving steps. Students with low SRL can carry out the stage of understanding the problem by writing down what is known but not writing down what is being asked but when being interviewed students can provide information from what is contained in the questions without any other additions. At the planning stage, students did not write down the completion steps and were unable to explain them. As a result, students do nothing in the evaluation stage so students with low SRL are only able to carry out one of the four problem solving stages.

Based on the results obtained, it can be concluded that the level of students' self-regulated learning (SRL) plays a crucial role in their problem-solving abilities. Students with high SRL can successfully complete all stages of problem-solving accurately and effectively. On the other hand, students with moderate SRL can only accomplish two out of four stages of problem-solving, while students with low SRL are unable to solve problems accurately but can comprehend explicit information present in the problem, allowing them to complete one out of the four overall stages of problem-solving.

REFFERENCES

Albab, I. U., Hartono, Y., & Darmawijoyo, D. (2014). Kemajuan Belajar Siswa Pada Geometri Transformasi Menggunakan Aktivitas Refleksi Geometri. *Jurnal Cakrawala Pendidikan*, *3*(3), 338–348. https://doi.org/10.21831/cp.v3i3.2378

Bailey, J. (2022). Learning to Teach Mathematics Through Problem Solving. *New Zealand Journal of Educational Studies*, *57*(2), 407–423. https://doi.org/10.1007/s40841-022-00249-0

Bayuningsih, A. S., Usodo, B., & Subanti, S. (2017). Analysis of Junior High School Students' Problem-solving Ability Reviewed from Self-regulated Learning. *International Journal of Science and Applied Science: Conference Series*, *2*(1), 51. https://doi.org/10.20961/ijsascs.v2i1.16678

Căprioară, D. (2015). Problem Solving - Purpose and Means of Learning Mathematics in School. *Procedia - Social and Behavioral Sciences*, *191*, 1859–1864. https://doi.org/10.1016/j.sbspro.2015.04.332

Corte, E. D. E. (2016). *Improving Higher Education Students ' Learning Pro fi ciency by Fostering their Self-regulation Skills*. *24*(2), 264–276. https://doi.org/10.1017/S1062798715000617

Cueli, M., Rodríguez, C., Areces, D., García, T., & González-Castro, P. (2017). Improvement of Self-regulated Learning in Mathematics through a Hypermedia Application: Differences based on Academic Performance and Previous Knowledge. *Spanish Journal of Psychology*, *20*, 1–14. https://doi.org/10.1017/sjp.2017.63

Darma, Y., Firdaus, M., & Haryadi, H. (2016). Hubungan Kemandirian Belajar Terhadap Kemampuan Pemecahan Masalah Matematis Mahasiswa Calon Guru Matematika. *Edukasi*, *14*, 169.

Dewi, S. K., Suarjana, M., & Sumantri, M. (2014). Penerapan Polya untuk Meningkatkan Hasil Belajar dalam Memecahkan Soal Cerita Matematika Siswa Kelas V. *Jurnal Mimbar PGSD Universitas Pendidikan Ganesa*, *1*(2).

Fathani, A. H. (2016). Rahmah Johar. "Domain Soal PISA untuk Literasi matematikaa". *Jurnal EduSains*, *4*(2), 136–150.

Ferreira, P. D. C., Ferreira, A. I., Veiga Simão, A. M. V. Da, Prada, R., Paulino, A. P., & Rodrigues, R. (2022). Self-Regulated Learning and Working Memory Determine Problem-Solving Accuracy in Math. *Spanish Journal of Psychology*, *25*(6), 1–17. https://doi.org/10.1017/SJP.2022.19

Granberg, C., Palm, T., & Palmberg, B. (2021). A case study of a formative assessment practice and the effects on students' self-regulated learning. *Studies in Educational Evaluation*, *68*(August 2020). https://doi.org/10.1016/j.stueduc.2020.100955

Handayani, A. S., & Ariyanti, I. (2021). Kemandirian Belajar Matematika Siswa SMP disaat Pandemi COVID-19. *UrbanGreen Conference Proceeding Library*, 6–10.

Hendriana, H., & Soemarmo, U. (2014). *Penilaian Pembelajaran Matematika*. Reflika Aditama.

Kluytmans, F. (2006). *Perilaku Manusi*. Refika Aditama.

Kramarski, B., Weisse, I., & Kololshi-Minsker, I. (2010). How can self-regulated learning support the problem solving of third-grade students with mathematics anxiety? *ZDM -*

International Journal on Mathematics Education, *42*(2), 179–193. https://doi.org/10.1007/s11858-009-0202-8

Kurnia, D., & Warmi, A. (2019). Analisis Self-Regulated Learning dalam Pembelajaran Matematika Pada Siswa SMP Kelas VIII Ditinjau dari Fase-Fase Self-Regulated Learning. *Jurnal Ilmiah Soulmath : Jurnal Edukasi Pendidikan Matematika*, *9*(1), 1.

Listiawan, T., & Antoni, A. (2021). Pengembangan Media Pembelajaran Matematika Berbasis Augmented Reality (AR) Pada Materi Transformasi Geometri. *JP2M (Jurnal Pendidikan Dan Pembelajaran Matematika)*, *7*(1), 43–52. https://doi.org/10.29100/jp2m.v7i1.2099

Machmurotun, S. (2014). (the Thinking Ability of Students in Solving Mathematics. *Journal Pendidikan Matematika*, *2*(2), 237–248.

Mahfuddin, M., & Caswita, C. (2021). Analisis Kemampuan Pemecahan Masalah Pada Soal Berbasis High Order Thinking Ditinjau Dari Kemampuan Spasial. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *10*(3), 1696. https://doi.org/10.24127/ajpm.v10i3.3874

NCTM. (2000). *Principles and Standards for School Mathematics*. NCTM.

Nur'aini, I. L., Harahap, E., Badruzzaman, F. H., & Darmawan, D. (2017). Pembelajaran Matematika Geometri Secara Realistis Dengan GeoGebra. *Matematika*, *16*(2), 1–6. https://doi.org/10.29313/jmtm.v16i2.3900

Nuryah, M., Ferdianto, F., & Supriyadi, S. (2020). Analisis Kesalahan Siswa dalam Menyelesaikan Soal Persamaan dan Pertidaksamaan Nilai Mutlak Berdasarkan Langkah Penyelesaian Polya. *Journal of Medives : Journal of Mathematics Education IKIP Veteran Semarang*, *4*(1), 63. https://doi.org/10.31331/medivesveteran.v4i1.983

Polya, G. (1973). *How to Solve it: A new Aspect of Mathematical Method. 2nd ed.* Princenton University Press.

Rachmawati, A. D., Kusumah, Y. S., & Juandi, D. (2021). Kemampuan Pemecahan Masalah Dan Kemandirian Belajar Menggunakan Pendekatan Stem Berbasis Lesson Study for Learning Community. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *10*(4), 2636. https://doi.org/10.24127/ajpm.v10i4.4416

Saputri, R. A. (2019). Analisis Pemecahan Masalah Soal Cerita Materi Perbandingan Ditinjau Dari Aspek Merencanakan Polya. *Wacana Akademika: Majalah Ilmiah Kependidikan*, *3*(1), 21–38. http://jurnal.ustjogja.ac.id/index.php/wacanaakademika/article/download/3267/2335

Sudirman, Cahyono, E., & Kadir. (2018). Analisis Kemampuan Koneksi Matematis Siswa SMP Pesisir Ditinjau dari Perbedaan Gender. *Jurnal Pembelajaran Berfikir Matematika*, *3*(2), 11–22. http://ojs.uho.ac.id/index.php/snrkt2017/article/view/3264

Suid, Syafrina, A., & Tursinawati. (2017). Analisis Kemandirian Siswa Dalam Proses Pembelajaran di Kelas III SD Negeri 1 Banda Anceh. *Jurnal Pesona Dasar*, *1*(15).

Sundayana, R. (2018). Kaitan antara Gaya Belajar, Kemandirian Belajar, dan Kemampuan Pemecahan Masalah Siswa SMP dalam Pelajaran Matematika. *Mosharafa: Jurnal*

Pendidikan Matematika, *5*(2), 75–84. https://doi.org/10.31980/mosharafa.v5i2.262

Udil, P. A., Kusmayadi, T. A., & Riyadi, R. (2017). Metacognition Process of Students with High Mathematics Anxiety in Mathematics Problem-Solving. *International Journal of Science and Applied Science: Conference Series*, *2*(1), 261. https://doi.org/10.20961/ijsascs.v2i1.16724

Wahyuddin. (2016). Analisis kemampuan menyelesaikan soal cerita matematika ditinjau dari kemampuan verbal. *Beta: Jurnal Tadris Matematika*, *9*(2), 148–160.

Yaniawati, R. P., Kartasasmita, B. G., & Saputra, J. (2019). E-learning assisted problem based learning for self-regulated learning and mathematical problem solving. *Journal of Physics: Conference Series*, *1280*(4). https://doi.org/10.1088/1742-6596/1280/4/042023

Zamnah, L. N. (2019). Analisis Self-Regulated Learning yang Memperoleh Pembelajaran Menggunakan Pendekatan Problem-Centered Learning dengan Hands-On Activity. *ANARGYA: Jurnal Ilmiah Pendidikan Matematika*, *2*(1). https://doi.org/10.24176/anargya.v2i1.3495

 Print ISSN: 2088-2157, Online ISSN: 2580-0779