INDONESIAN JOURNAL OF SCIENCE AND MATHEMATICS EDUCATION
https://ejournal.radenintan.ac.id/index.php/IJSME/index
05 (2) (2022) 156-168
ISSN: 2615-8639
DOI: 10.24042/ijsme.v5i1.11182
July 2022

EXPLORATION OF MATHEMATICS PROBLEM SOLVING PROCESSES OF JUNIOR HIGH SCHOOL STUDENTS WITH DIFFERENT LEVELS OF LOGICAL THINKING ABILITY

Tika Nurhalisa[1], Isnainy Ibnatul Azizah[2], Firdaus Qoofa Putri Tsania[3], Warli[4*]
[1,2,3,4]Department of Mathematics Education, Universitas PGRI Ronggolawe, Tuban, Indonesia

**Corresponding author:* warli66@gmail.com

Article Info

Article history:

Received: January 15, 2022
Accepted: June 13, 2022
Published: July 20, 2022

Keywords:

Attack
Entry
Logical thinking
Problem-solving
Review

ABSTRACT

Problem solving is one of the most important skills for students. Meanwhile, logical thinking is the ability to solve problems by relying on mental abilities. The purpose of this research is to describe the problem solving process of students with different levels of logical thinking. This research is an exploratory qualitative research involving eighth grade students of SMP N 5 Tuban who have different levels of logical thinking as research subjects. The subjects who were interviewed were 4 students. Instruments to measure the level of logical thinking used The Group Assessment of Logical Thinking (GALT) while exploring the process of solving problems using the stages of entry, attack, and review. The results of the analysis show that students with high logical thinking skills meet the entry, attack, and review stage. Students with low logical thinking skills meet the entry stage in 'know' and 'want' aspects only, at the attack stage they only meet the try and possible aspects, and do not meet the review stage at all. Thus, it can be concluded that students with different levels of logical thinking ability have different mathematical problem solving abilities.

EKSPLORASI PROSES PEMECAHAN MASALAH MATEMATIKA SISWA SMP DENGAN TINGKAT KEMAMPUAN BERPIKIR LOGIS BERBEDA

Kata Kunci:

Memahami
Mengerjakan
Berpikir logis
Pemecahan masalah
Meninjau

ABSTRAK

Pemecahan masalah merupakan salah satu kemampuan yang sangat penting bagi siswa. Sementara itu, berpikir logis merupakan kemampuan dalam memecahkan masalah dengan menerapkan kemampuan mental. Tujuan dari penelitian ini untuk mendeskripsikan proses pemecahan masalah siswa dengan tingkat berpikir logis yang berbeda. Penelitian ini merupakan penelitian kualitatif eksploratif dengan subjek penelitian siswa kelas VIII SMP N 5 Tuban yang memiliki tingkat berpikir logis yang berbeda. Subjek yang diwawancarai adalah sebanyak 4 siswa. Instrumen yang digunakan untuk mengukur tingkat berpikir logis adalah *The Group Assessment of Logical Thinking* (GALT), sedangkan untuk menggali proses pemecahanan masalah siswa menggunakan tahapan *entry*, *attack*, dan *review*. Hasil analisis menunjukkan bahwa siswa dengan kemampuan berpikir logis tinggi memenuhi tahap *entry*, *attack*, dan *review*. Siswa dengan kemampuan berpikir logis rendah memenuhi tahap *entry* pada aspek tahu dan ingin, memenuhi tahap *attack* pada aspek coba dan mungkin, dan tidak memenuhi tahap *review*. Dengan demikian

dapat disimpulkan bahwa siswa dengan tingkat kemampuan berpikir logis berbeda memiliki kemampuan pemecahan masalah matematika yang berbeda pula.

1. INTRODUCTION

According to Santrock, thinking is the process of processing and transforming information in memory [1]. While the thinking process is a mental activity that is used to formulate and solve problems, make decisions and understand problems [2]. From this definition, decision-making is very much influenced by the high and low levels of the thinking process. With various reviews of students' thinking processes, it can be traced to Polya's as cited in [3] problem solving steps, namely understanding problems, planning solutions, implementing solutions, and reviewing the solutions that have been made. The thought process can also be traced to the stages of [4].

Problem solving is one of the overall general goals of the curriculum [5], and an important part of the mathematics curriculum, because students can use problem solving skills to be applied in solving everyday problems and become needs in mathematics curricula around the world [6]. In addition, one of the seven 21st century skills according to Wagner's (2010) as cited in [7] identification is critical thinking and problem solving. In learning mathematics, higher-order thinking skills (HOTS) include several abilities, including communication, creativity, problem solving, and mathematical reasoning [8], [9]. For this reason, knowing how the student's problem solving process in detail is needed to improve learning that is oriented toward increasing problem solving abilities. The difference in students' logical thinking becomes one of the important aspects to investigate because the mathematical problem solving process relies on students' logical thinking and each student has different logical thinking abilities. Given the importance of the role of problem solving in learning, the Indonesian government issued a policy through Permendikbud No. 54 of 2013 that the 2013 curriculum in learning recommends using learning models that begin with problems, for example, problem-based learning, project-based learning, and discovery learning. And its implementation is emphasized through a scientific approach with the aim that students have a description of attitudes, knowledge, and skills for each educational unit [10]

In learning mathematics, the use of problem solving strategies has an impact on students' abilities and skills. The results showed that the problem solving approach had an effected on students' learning abilities and achievement [11], [12], made it easier for students to solve difficult problems [13], and contributed to student achievement. and knowledge development [14], [15]. The level of achievement of students who are taught using problem solving methods is different and better than conventional teaching methods [16], [17]. The goal in learning mathematics is not only taught to count, but students are expected to be able to improve their logical, analytical, and systematic thinking skills and be able to apply them in everyday life so that they can solve problems in mathematics [18]. To solve problems in mathematics requires reasoning that involves logic, such as the ability to think logically. The ability to think logically is the ability to think that uses logic to solve a problem or think about an event or reality that may occur [19].

This research explored the problem solving process of students with different levels of logical thinking. Logical thinking is one way that can be used to obtain advanced mental activity. Thus, the ability to think logically is an activity that depends on the level of knowledge and understanding of the stages of the cognitive field of purpose Bozdogan

in [20]. Furthermore, Bozdogan explained that logical thinking is the ability to show behavior such as effective use of numbers, analyzing relationships between concepts, hypothesizing, making problem solutions, categorizing, generalizing, disclosing, and mathematical formulas, calculating, checking, and assimilating [20]. According to Yaman [20], the ability to think logically is one of the cognitive skills that affects students. The ability to think logically focuses on an individual's ability to solve problems by applying his or her mental ability to produce principles or rules by creating certain abstracts or generalizations. Meanwhile, according to Kamanee, logical thinking is thought that can be included in reasoning that is used to reason to solve problems and use symbols that are known [21]. Piaget said that the concrete and abstract operation stages can be used to observe logical thinking processes. Concrete problems at the concrete operational stage can be solved using students' logical thinking skills [20]. With the existence of logical thinking, a person is not ambiguous in solving problems [22]. Based on some of the opinions above, it can be said that problem solving is an important competency that must be developed in students. To develop mathematical problem solving skills, the foundation is the students' logical thinking ability. One's logical thinking depends on the level of knowledge and understanding of each student. For this reason, it is important to research the exploration of problem solving processes in children with different logical thinking abilities, as a basis for designing learning in developing problem solving abilities.

Problem solving methods are most commonly used in the development of logical thinking skills. The path of logical thinking means getting facts, ideas, and results of a problem and arranging them in an orderly and sequential manner [20]. The problem solving process in this study was observed based on the stages of [4]. When someone wants to solve a problem, they must go through three stages, namely the entry, attack, and review stages [4]. The entry stage has three aspects, namely know, want, and introduce. While some indicators at the entry stage, namely students understand the questions carefully and group and sort information. Just like the entry-stage resistance to attack also has three aspects, namely try, maybe, and why. Meanwhile, the indicator at the attack stage is to propose an allegation on the completion of the problem and to try the allegations of solving the problem. Whereas in the review there are also three aspects, namely check, reflect, and extend. Meanwhile, one of the indicators at the review stage is checking the accuracy of the calculation of the problem solving process

Problem solving is a process that applies knowledge and skills to achieve goals [23]. Problem solving is like the heart of learning mathematics because it is not only for learning the subject, but this skill also emphasizes the development of thinking methods. Determining a problem solving solution is one of the main aspects of the mathematics curriculum that students need to apply and integrate several concepts and skills [24]. According to Wardani, problem solving is a medium for developing mathematical knowledge and is a characteristic of mathematics [25].

Based on the opinions of experts about problem solving, it can be said that problem solving is one of the most important aspects to be applied in schools with the aim that students have problem solving abilities as student needs to be applied in everyday life. By having problem solving skills, students can analyze problems and synthesize solutions [26]. Referring to those statements, students' thinking skills greatly influence the process of solving mathematical problems. One of the very important thinking skills in solving mathematical problems is logical thinking skills. Therefore, the researcher conducted this research to explore how the problem solving process of students who have different levels of logical thinking on the topic of circles. The purpose of this study was

to describe the exploration of the problem solving process of students who have different levels of logical thinking on the topic of circles. Based on the analysis of the expert opinion above, it can be said that the ability to think logically has an important role in solving mathematical problems. Logically, if students have high logical thinking skills, the mathematical problem solving process will be better, and vice versa, this is as in [27] students with good problem solving abilities tend to think logically well. [27] Identifies logical thinking in problem solving, while this study explores the problem solving process in terms of students who have different logical thinking because researchers have the assumption that problem solving is based on logical thinking. However, it is found that students who have high logical thinking skills sometimes still have difficulty in solving problems, because they do not understand the use of the basic knowledge they have or relate the concepts needed in solving problems.

Research on mathematical problem solving skills is in great demand, several previous studies have revealed that the problem solving process is based on the level of thinking [3], [28], there are also studies that examined problem-solving skills based on gender differences [29]-[31], several others studied mathematical problem solving from a reflective and field-dependent cognitive style [32], [33], mathematics problem-solving based on mathematics skills [31], the effect of means-ends analysis learning model on mathematics problem solving [34], the effect of means-ends analysis learning model on mathematics problem solving [35]. However, research that specifically explores the process of solving mathematical problems with different levels of logical thinking skills has never been done. There are similar studies that discuss problem-solving with logical thinking skills [36] which only discusses problem-solving, not specifically in mathematics problem-solving. Hence, it is necessary to conduct research that can provide an update on the exploration of the mathematical problem-solving process of junior high school students by reviewing it from different levels of logical thinking. This study aims to describe the mathematical problem-solving process of students with different levels of logical thinking.

2. METHOD

The purpose of this study was to describe the problem solving process in junior high school students with different levels of logical thinking. Based on the research objectives, the researcher conducted problem solving tests for junior high school students with topics or circle problem solving materials, then to assess the problem solving process of junior high school students, researchers conducted interviews with junior high school students with different levels of logical thinking. Interviews were conducted based on students' answers during problem solving tests and were reviewed based on the problem solving stages developed by Mason et al [4]. Based on this, this type of research is qualitative exploratory research.

The subjects of this study were students of class VIII who had different levels of logical thinking. Place of research at SMP Negeri 5 Tuban. To determine the level of logical thinking of students, the instrument The Group Assessment of Logical Thinking/GALT is used [37]. To get the research subjects, namely students who have high and low logical thinking skills, after a logical thinking test is carried out, the average score of logical thinking skills is analyzed. If students have a logical thinking score above the average, then they are included in the group of students with high logical thinking ability, and vice versa. The total number of students who were measured for logical thinking was 34 students, 12 students were above the average (high logical thinking) and 22 students were below the average (low logical thinking). To select

subjects to be interviewed, the results of the measurement of logical thinking were grouped into 2, high and low. Then from the high and low groups, two students will be taken into consideration.

a. The first two groups had high logical thinking scores and the remaining two groups had low scores; and
b. Able to communicate verbal and written answers to problem solving work.

Then based on the results of the study, the selected subjects were AW and IND with high logical thinking scores, while those with low logical thinking scores were JG and RP.

To find out the problem solving ability, a problem solving ability test was carried out which consisted of 3 questions with a circle topic. The three problems used in the problem-solving test include a) the problem of a circle connected to a plane (rhombus); b) circle problems related to daily life (creating a garden), and c) circle problems related to other fields of study (natural sciences). Before being used this problem solving test has been validated by mathematics teachers and mathematics lecturers and has been declared valid. To dig up information about the problem solving process using an interview guide instrument. Interviews were conducted in a structured manner, interview questions referred to the stages of problem solving based on Mason stages [4].

Table 1. Problem Solving Stages [4]

Step	Aspect	Indicator
Entry	Knows	• Understand the problem carefully • Trying to find the things involved with the question like what is known and what is being asked in the question
	Want	• Want to group and sort information • Want to solve the problem
	Introduce	• Choose any elements that need to be in the form of symbols or choose what symbols to use • Compile what is known from the problem.
Attack	Try	• Submit allegations regarding problem-solving • Modifying wrong guesses to be true.
	Maybe	Trying the guesswork that has been made whether it can solve the problem or not.
	Why	• Have logical reasons for accepting or rejecting an allegation. • Convince other people that every step of the solution is done verbally or in writing by presenting systematic settlement steps
Review	Check	• Check the accuracy of calculations • Check the accuracy of the reasons at the completion step. • Check the suitability of the complete steps with questions
	Reflect	• Reflect on the ideas in progress, which parts are difficult, and what can be learned from the completion • Reflecting on the provisional conjectures.
	Extend	• Make the general form of the results obtained so that they can be used in a wider context • Looking for other solutions • Trying to solve similar problems by changing the facts and things you want to ask.

The analysis was carried out after the interview process was carried out. Researchers conducted data analysis using qualitative methods. Overall the research procedure can be presented in the research flow chart in Figure 1.

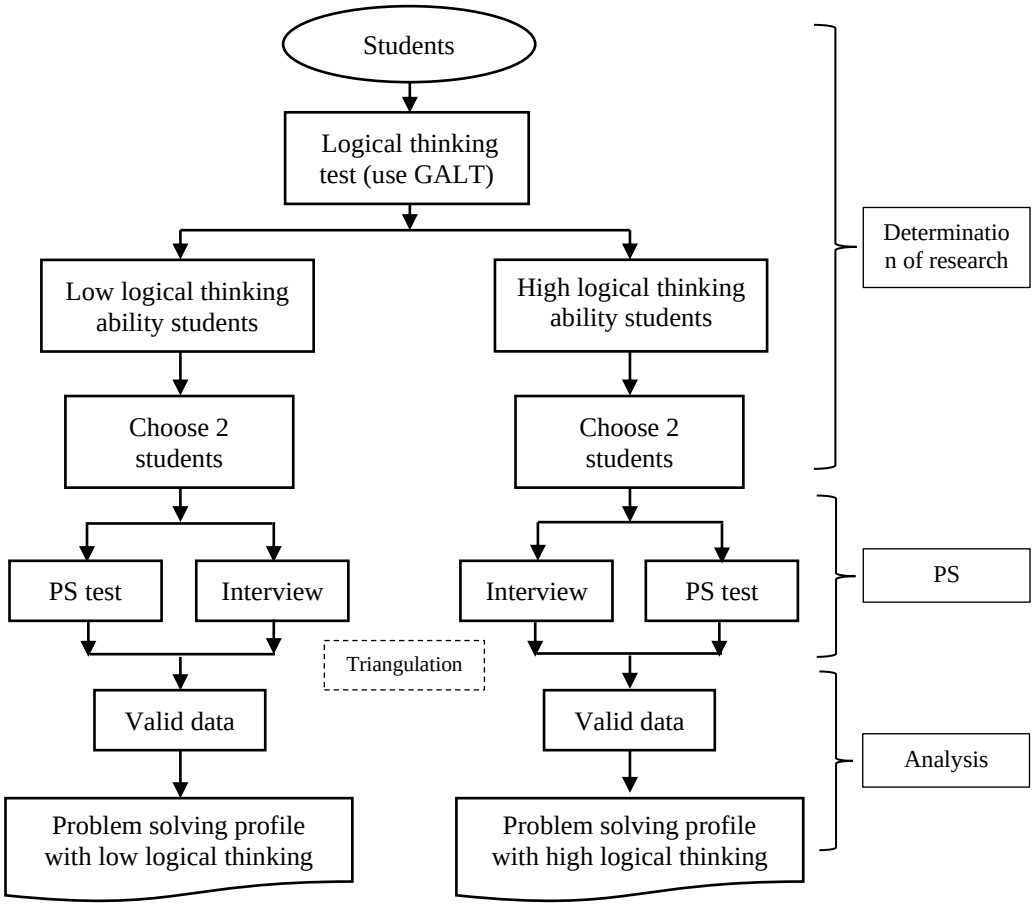

Figure 1. Research Flowchart

The existing data is analyzed qualitatively, this analysis is carried out by processing the data, organizing the data, selecting it into manageable units, synthesizing, finding patterns, finding important things to learn, and deciding what to tell [38]. Referring to this opinion, there are five stages of qualitative data analysis carried out, namely examining all data, reducing, categorizing data, coding, and making conclusions descriptions. To see the validity of the data, triangulation methods were used, namely the problem solving test method, and the interview method using equivalent questions. The data is said to be valid if the description of the results of the analysis of tests and interviews is relatively the same. The test results were analyzed based on Mason stages (entry, attack, and review with all sub-indicators). The same thing was done for the data from the interviews that were analyzed qualitatively, namely checking all the data, reducing, categorizing the data, coding, and making a description of the conclusions based on Mason's stages. Furthermore, to obtain valid data, a comparison is made between the results of the test and interview analysis. Valid data is used as the basis for describing the problem solving process.

3. RESULTS AND DISCUSSION

Problem solving abilities are seen from 2 different subjects, namely subjects with high logical thinking scores and subjects with low logical thinking scores. Based on the description above, the selected subjects are AW and IND with high logical thinking scores, while those who have low logical thinking scores are JG and RP. Following are the results and discussion of selected subjects.

3.1 The Process of Solving the Problem of Subjects who have High Logical Thinking Skills.

The ability to solve problems based on Mason stages by subjects who have a high level of logical thinking on the topic of circle problems.

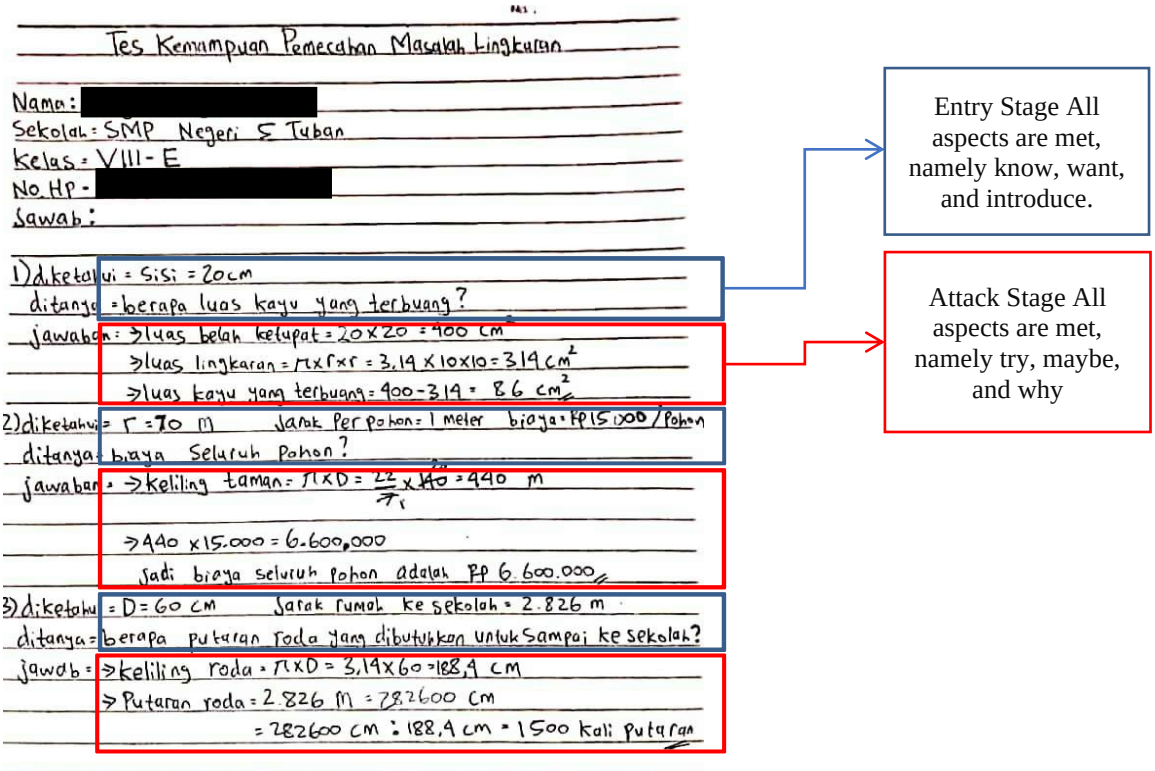

Figure 2. AW Answer Results When Solving Circle Problems

3.1.1 Stages of Entry

The problem solving process with the stages of Mason et al. students who have logical thinking skills (AW) can be observed well. Based on the entry stages, AW fulfills the know, want, and introduce aspects. The knowing aspect is fulfilled because AW can find what is known and asked. The results of the work also show that AW can sort the information contained in the problem given, this shows that AW fulfills the wanted aspect. In addition, AW also fulfills the aspect of introducing because AW calculates elements such as calculating sides with s, radius with r, and diameter with d. The results of solving problems carried out by AW are shown in Figure 1.

For the second subject with high logical ability, IND also fulfills the entry stage. The entry stage is fulfilled because all aspects that exist at this stage have been implemented the same as AW. It's just that in answer to number 3 IND there is an error in entering the mileage information. In question number 3 the distance is 2,826 m, but IND includes a distance of 2,826 cm. This is because InIs is not careful in reading the questions which makes him wrong in terms of units.

From the explanation of the two subjects, it can be concluded that someone who has high logical thinking skills also can think in a good problem solving process, which fulfills the entry stage in the process of solving it. They can find out exactly what information is in the problem and sort out the elements that exist and know what is at issue or questionable. This is in line with the results of [39] research where the subject under study with good thinking processes in solving problems can fulfill all aspects of

the entry stage. In addition, this research is also in line with [28] that the subjects studied with high abilities can fulfill all aspects of the entry stage.

3.1.2 Stages of Attack

Based on the answer to the problem solving process, it appears that AW can explain the resolution process well. Therefore, at the attack stage, AW fulfills the try, maybe, and why aspects. The try aspect is fulfilled because the answer to number 1 shows that AW makes an initial prediction of completion by calculating the area of the rhombus shape and the area of the circle shape and then reducing the area of the rhombus to the area of the circle so that the area of the wasted part can be known. In answer to number 2, the trying aspect is also fulfilled because AW can make an initial estimate of completion, namely by calculating the circumference of the park and then multiplying it by the cost per tree so that the overall tree cost can be found. Likewise in answer to number three AW can also make an initial guess by calculating the circumference of the wheel and then dividing the distance by the circumference of the wheel to find the number of revolutions. All the guesses made have been tried. Is it able to solve the problem or not. This is by following per under the maybe aspect. In addition, AW can also convince other people in writing that the completion steps taken are correct and are resolved systematically. This is by following per under the why aspect. For the second subject with high logical ability, IND also fulfills all aspects of the attack stage. However, due to inaccuracy, which led to incorrectly entering the information in question number 3, it made IND unable to convince other people that the steps to solve question number 3 were correct.

From the two subjects, it can be concluded that someone who has high logical thinking skills can think well in processing the information in the problem so that it meets the attack stage. All aspects of try, maybe, and why can be fulfilled. This is in line with the results of [39] research where the subjects she studied were able to fulfill the try, maybe, and why aspects in the process of solving problems. In addition, this research is also in line with [28] that the subjects studied with high abilities can fulfill all aspects of the attack stage.

3.1.3 Stages of Review

Based on the results of the interview at the review stage, AW fulfills the check and reflect stage. The check aspect is fulfilled because when working on AW, check the answer again. Besides AW, it also fulfills the reflect aspect because the subject can reflect on the assumptions in completion. But at this stage, AW does not apply the extended aspect. Following are the results of interviews between researchers and students (AW) at the review stage.

Researchers : *Did you check all the answers before you submitted them?*
AW : *Yes sis, I checked all the answers*
Researchers : *Are you sure that your answer is correct?*
AW : *Yes sis, I am really thinking about the answer and I am sure it is true*
Researchers : *Good, keep up the spirit and always be successful*
AW : *Aamiin ... Thank you sis*

The second subject with high logical thinking skills (IND) fulfills the Reflect stage. It's just that IND did not check the answer because he was in a hurry with time, so there was an error entering the information in question number 3 without him knowing it. This stage also IND does not apply the extended aspect. Following are the results of interviews between researchers and students (IND) at the review stage.

Researchers : *Did you check all the answers before you submitted them? And are you sure your answers are correct?*
IND : *No, because I am in a hurry to do my work, I am also not sure of the truth*
Researchers : *Because you didn't read the question again and check the answer, you had an error entering the information on one of the questions that you didn't realize. Next time be more careful*
IND : *Yes, sorry, sis, be more careful next time*

From the description of the two subjects, it can be concluded that someone who has high logical thinking skills fulfills the review stage. This is in line with the results of [39] where the subject under study can solve problems with the correct process and check and reflect in the final stage. In addition, this research is also in line with [28] that the subjects studied with high abilities can fulfill all aspects of the review stage.

3.2 The Problem Solving Process of Subjects who have Low Logical Thinking Skills

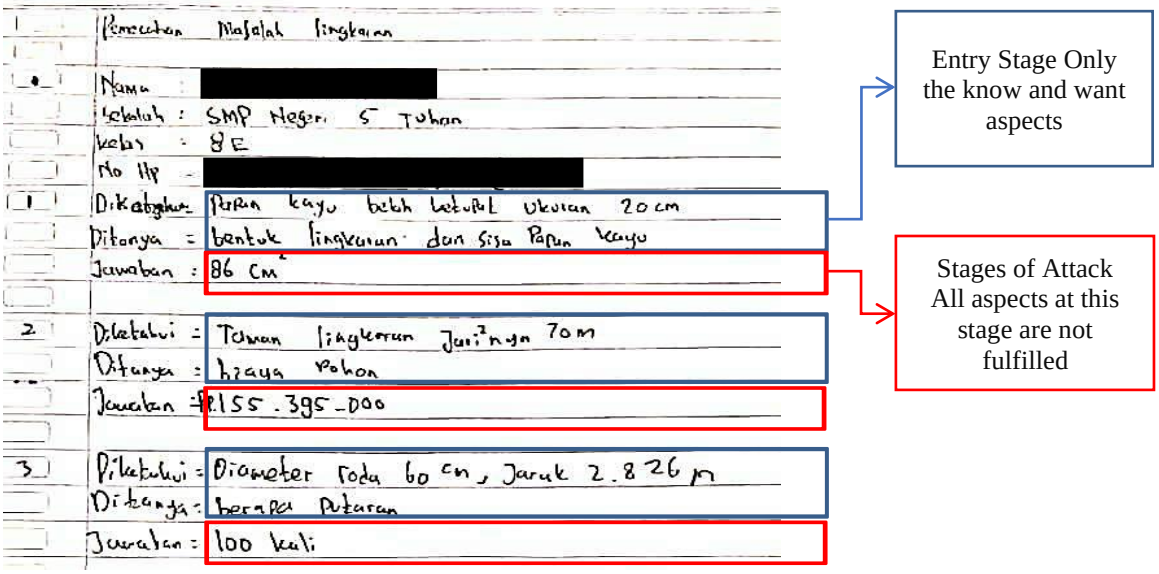

Figure 3. Results of JG's Answers When Solving Circle Problems

3.2.1 Stages of Entry

The results of the students' answers to low logical thinking skills (JG) when solving problems showed that JG was not able to solve the problems given. Based on the entry stages, JG only fulfilled the know and want aspects. The knowing aspect was fulfilled because JG was able to find out what he knew and what was asked. At this stage, JG fulfills the wanted aspect because JG lists all available information. At this stage the introduce aspect was also not fulfilled because JG did not take into account the elements that were in the problem.

For the second subject with low logical ability, the RP also does not fulfill the entry stage. Several aspects of the entry stages are not fulfilled. RP only states what is asked as the knowledge aspect. RP does not fulfill the wanted aspect because it does not sort the information. At this stage, the RP also does not apply the introduce aspect.

From the explanation of the two subjects, it can be concluded that someone who has low logical thinking ability, has low problem solving processability, where the solving process does not meet the entry stage. Students are only able to fulfill the know and want aspects. They cannot fulfill the introduce aspect. This is in line with the results of [39] where the subjects studied with low thinking skills in solving problems only fulfill the know and want aspects.

3.2.2 Stages of Attack

Based on the answer to the problem solving process, it appears that JG is not able to explain the resolution process properly. It appears that JG is not able to apply the attack stage. JG was unable to give conjecture on the trying aspect, did not try to guess on the maybe aspect, and could not ensure that the answer was systematic and correct by applying the why aspect. The second subject with low logical thinking skills (RP) is not able to apply the attack stages properly. RP only fulfills the try and maybe aspect. However, RP does not fulfill the why aspect because it cannot convince people with systematic and correct answers.

From the two subjects, it can be concluded that someone who has low logical thinking skills is less able to think well in processing the information in the problem so that only a few aspects fulfill the attack stage. Students can only fulfill the try until maybe aspect. This is in line with the results of [39] research where the subjects studied in the low problem solving thought process only fulfilled the trying aspect.

3.2.3 Stages of Review

Based on the results of the interview on solving the problem, JG did not fulfill the review stage. JG applies the check aspect because JG checks the answers again before they are collected. On the reflect aspect, JG cannot reflect on expectations and does not apply the extended aspect. Following are the results of interviews between researchers and students (JG) at the review stage.

Researchers : *Did you check all the answers before you submitted them?*
JG : *Yes, sis*
Researchers : *Are you sure that your answer is correct?*
JG : *I'm not sure sis*

The second subject with low logical thinking skills (RP), does not fulfill the review stage. It only fulfills the aspects of check and reflection. The check aspect is fulfilled because he checks the answers before they are collected, but at the time of checking, he re-reads the questions but was not thorough so that there was wrong information he entered. RP fulfills the reflect aspect because RP reflects on the answer and believes that the answer is correct. RP does not fulfill the extended aspect. Following are the results of interviews between researchers and students (RP) at the review stage.

Researchers : *Did you check all the answers and reread the questions before you submitted them?*
RP : *Yes, I checked and reread it*
Researchers : *Did you read the questions carefully?*
RP : *Looks like it's not accurate, sis.*
Researchers *: Are you sure that your answer is correct?*
RP *: I'm not sure sis*

From the explanation of the two subjects, it can be concluded that someone who has low logical thinking skills does not fulfill the review stage. At this stage, students only check the answers, but they are not careful, so they do not know whether the answer can solve the problem or not. This is in line with the results of [39] study, where the subject under study did not know whether his guess could solve the problem or not. Likewise, the results of research [40] show that students' logical thinking abilities are very low with an average value of 22.76%. More than half of the students could not give the correct answer to the given task and also could not give a reason for their answer. And the results of [27] show that the logical thinking skills of junior high school students are still low, have not been able to plan problem solving steps, have not been able to give arguments and conclude correctly.

4. CONCLUSION

Based on the results of the analysis and discussion, it can be concluded that students with high logical thinking ability process the problem solving according to Mason's stages can be done correctly and systematically. Meanwhile, students with low logical thinking skills have not been able to carry out the problem-solving process correctly and systematically. It can be described in detail as follows. Students with high logical thinking skills can solve problems based on Mason's stages correctly. Based on the entry-stage, students with high logical thinking can fulfill all aspects, namely aspects of know, want, and introduce. At the stage of solving the problem, students with high logical ability can submit conjectures and try existing conjectures and convince others with correct and systematic answers. This fulfills the attack stage with aspects of try, maybe, and why. At the review stage, students carry out this process by checking and reflecting on aspects. Students with low logical thinking ability are less able to understand the meaning of the problem. At the entry stage, students can only fulfill the know and want aspects. At the attack stage, students only apply the try and maybe aspects. Then why the aspect is not fulfilled because they cannot make sure the answer is correct and systematic. At the review stage, students are less able to apply existing aspects. Students check and reflect on answers but not carefully.

ACKNOWLEDGMENT

We would like to thank the Head of the Mathematics Education Study Program of UNIROW Tuban and the Head of SMP N 5 Tuban who have permitted this research so that this research can be carried out properly.

REFERENCES

[1] J. W. Santrock, "Perkembangan Anak Edisi 6 Jakarta: Salemba Medika," 2011.
[2] D. D. Subanji, "Proses Berpikir Penalaran Kovariasional Pseudo Dalam Mengkonstruksi Grafik Fungsi Kejadian Dinamika Berkebalikan." Surabaya: PPs Unesa, 2007.
[3] A. Rahman and A. Saleh Ahmar, "Correspondence Ansari Saleh Ahmar Exploration of Mathematics Problem Solving Process Based on The Thinking Level of Students in Junior High School Open Access," *Int. J. Environ. Sci. Educ.*, vol. 11, no. 14, pp. 7278–7285, 2016.
[4] J. Mason, L. Burton, and K. Stacey, *Thinking Mathematically*, Second Edi. 2010.
[5] E. Pehkonen, "Problem solving in mathematics education in Finland," *Proc. ICMI Symp.*, no. Ncsm, pp. 7–11, 2008.
[6] M. Santos-Trigo, *Problem Solving in Mathematics Education*. 2014.
[7] M. Cevik and C. Senturk, "Cypriot Journal of Educational Multidimensional 21st century skills scale : Validity and reliability study," vol. 14, no. 1, pp. 11–28, 2019.
[8] S. M. Brookhart, *Assess Higher-Order Thinking Skills In Your Classroom*, vol. 88, no. 18. 2010.
[9] A. Madu, "Higher Order Tingking Skills (Hots) In Math Learning Aleksius Madu," vol. 13, no. 5, pp. 70–75, 2017.
[10] Kementrian Pendidikan dan Kebudayaan Republik Indonesia, "Peraturan Menteri Pendidikan Dan Kebudayaan Republik Indonesia Nomor 54 Tahun 2013 Tentang Standar Kompetensi Lulusan Pendidikan Dasar Dan Menengah," *Lembaran Negara RI*, vol. 53, no. 9, pp. 1689–1699, 2013.
[11] R. Ali, D. Hukamdad, A. Akhter, and A. Khan, "Effect of Using Problem Solving

Method in Teaching Mathematics on the Achievement of Mathematics Students," vol. 6, pp. 67–72, 2010.
[12] K. Perveen, "Effect Of The Problem-Solving Approach On Academic Achievement Of Students In Mathematics At The Secondary Level," *Contemp. Issues Educ. Res.*, vol. 3, no. 3, p. 9, 2010.
[13] T. Ozturk and B. Guven, "Evaluating students' beliefs in problem solving process: A case study," *Eurasia J. Math. Sci. Technol. Educ.*, vol. 12, no. 3, pp. 411–429, 2016.
[14] B. I. Sappaile and N. Djam'An, "The influence of problem-solving methods on students' mathematics learning outcomes," *Glob. J. Eng. Educ.*, vol. 19, no. 3, pp. 267–272, 2017.
[15] J. Perdomo-Díaz, P. Felmer, V. Randolph, and G. González, "Problem solving as a professional development strategy for teachers: A case study with fractions," *Eurasia J. Math. Sci. Technol. Educ.*, vol. 13, no. 3, pp. 987–999, 2017.
[16] M. Ghulam Behlol, A. Akbar, and H. Sehrish, "Effectiveness of Problem Solving Method in Teaching Mathematics at Elementary Level," vol. 40, no. 1, pp. 245–258, 2018.
[17] Y. H. Hu, J. Xing, and L. P. Tu, "The effect of a problem-oriented teaching method on university mathematics learning," *Eurasia J. Math. Sci. Technol. Educ.*, vol. 14, no. 5, pp. 1695–1703, 2018.
[18] S. Sevgi and K. Arslan, "Exploring Middle School Students Mathematics Self-Efficacy and Mathematics Anxiety.," *Online Submiss.*, vol. 7, no. 2, pp. 41–61, 2020.
[19] Ö. Koray and M. S. Köksal, "The effect of creative and critical thinking based laboratory applications on creative and logical thinking abilities of prospective teachers," *Asia-Pacific Forum Sci. Learn. Teach.*, vol. 10, no. 1, 2009.
[20] N. Sezen and A. Bülbül, "A scale on logical thinking abilities," *Procedia - Soc. Behav. Sci.*, vol. 15, pp. 2476–2480, 2011.
[21] I. Pornsawan and S. Charan, "Design and development of Adaptive Coaching System to enhance the Logical Thinking Model in Problem-Based Learning," *Eur. J. Soc. Sci.*, vol. 28, no. 4, pp. 444–451, 2012.
[22] L. Pezzuti, D. Artistico, A. Chirumbolo, L. Picone, and S. M. Dowd, "The relevance of logical thinking and cognitive style to everyday problem solving among older adults," *Learn. Individ. Differ.*, vol. 36, pp. 218–223, 2014.
[23] T. A. Girl, L. K. M. Wah, G. N. Kang, and C. L. Sai, "New Paradigm for Science Education. A Perspective of Teaching Problem-Solving, Creative Teaching and Primary Science Education." Singapore: Prentice Hall, 2002.
[24] T. Tambychik and T. S. M. Meerah, "Students' difficulties in mathematics problem-solving: What do they say?," *Procedia - Soc. Behav. Sci.*, vol. 8, no. 5, pp. 142–151, 2010.
[25] S. Wardani and E. Purnomo, Sapon Suryo Wahyuningsih, "Pembelajaran Kemampuan Penyelesaian masalah Matematika Di SD," *Yogyakarta Dep. Pendidik. Nas.*, 2010.
[26] Z. M. P. A. Baidowi, N. M. Noh, and N. A. M. Noh, "A Study on the Significance of Students' Thinking Level to Students' Performance," *Procedia - Soc. Behav. Sci.*, vol. 90, no. InCULT 2012, pp. 914–922, 2013.
[27] B. Andriawan, "Identifikasi Kemampuan Berpikir Logis Dalam Pemecahan Masalah Matematika Pada Siswa Kelas VIII-1 SMP Negeri 2 Sidoarjo," *MATHEdunesa*, vol. 3, no. 2, pp. 42–48, 2014.

[28] F. I. Firdaus and U. Siliwangi, "Deskripsi Proses Berpikir Matematis Siswa Dalam Memecahkan Masalah Konsep Barisan Berdasarkan Teori Mason," *J. Educio FKIP UNMA*, vol. 6, no. 2, pp. 711–720, 2020.
[29] W. Lestari, T. A. Kusmayadi, and F. Nurhasanah, "Kemampuan Pemecahan Masalah Matematika Ditinjau Dari Perbedaan Gender," *AKSIOMA J. Progr. Stud. Pendidik. Mat.*, vol. 10, no. 2, p. 1141, 2021.
[30] P. W. C. Davita and H. Pujiastuti, "Anallisis Kemampuan Pemecahan Masalah Matematika Ditinjau Dari Gender," *Kreano, J. Mat. Kreat.*, vol. 11, no. 1, pp. 110–117, 2020.
[31] E. Azhar, Y. Saputra, and I. Nuriadin, "Eksplorasi Kemampuan Pemecahan Masalah Matematis Siswa pada Materi Perbandingan Berdasarkan Kemampuan Matematika," vol. 10, no. 4, pp. 2129–2144, 2021.
[32] S. Rismen, R. Juwita, and U. Devinda, "Profil Kemampuan Pemecahan Masalah Matematika Siswa Ditinjau Dari Gaya Kognitif Reflektif," *J. Cendekia J. Pendidik. Mat.*, vol. 4, no. 1, pp. 163–171, 2020.
[33] L. W. Nengsih, S. Susiswo, and C. Sa'dijah, "Kemampuan Pemecahan Masalah Matematika Siswa Sekolah Dasar dengan Gaya Kognitif Field Dependent," *J. Pendidik. Teor. Penelitian, dan Pengemb.*, vol. 4, no. 2, p. 143, 2019.
[34] A. Sahrudin, "Implementasi Model Pembelajaran Means- Ends Analysis Untuk Meningkatkan Kemampuan Pemecahan Masalah Matematika Mahasiswa," *J. Pendidik. Unsika*, vol. 4, no. 1, pp. 17–25, 2016.
[35] H. Hasbullah and S. U. Sajiman, "Eksplorasi kemampuan pemecahan masalah matematika siswa melalui kecerdasan logika matematika," *Simp. Nas. Ilm. Call Pap. Unindra*, no. November, pp. 171–177, 2019.
[36] H. G. Seyhan, "The effects of problem solving applications on the development of science process skills, logical thinking skills and perception on problem solving ability in the science laboratory," *Asia-Pacific Forum Sci. Learn. Teach.*, vol. 16, no. 2, pp. 1–31, 2015.
[37] V. Roadrangka, "The construction of a group assessment of logical thinking (GALT)," *The annual meeting of the National Association for Research in Science Teaching*. pp. 5–8, 1983.
[38] Warli, I. Cintamulya, and P. Rahayu, "Scaffolding process based on students diagnostic difficulties in proving group problems by using mathematics mapping," *J. Phys. Conf. Ser.*, vol. 1422, no. 1, 2020.
[39] K. K. Wulan, Wardhani anindya, "Proses Berpikir Siswa Berdasarkan," no. October, pp. 297–313, 2016.
[40] R. Syafitri, Z. H. Putra, and E. Noviana, "Fifth Grade Students' Logical Thinking in Mathematics," *J. Teach. Learn. Elem. Educ.*, vol. 3, no. 2, p. 157, 2020.