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The Students' Thinking Level in Solving Mathematics Problems Based on SOLO Taxonomy as Viewed from the Mathematics Anxiety

Ratri Candra Hastari [1], Dewi Anggreini [2], Kiki Wiyanti[1]

[1] *Universitas Bhinneka PGRI Tulungagung*
[2] *Universitas Sarjanawiyata Tamansiswa*
anggreini1104@gmail.com

Abstract. *The SOLO (Structure of Observed Learning Outcome) taxonomy is an educational taxonomy suitable for organizing various types of learning. The SOLO taxonomy categorizes students' thinking into five levels: pre-structural, uni-structural, multi-structural, relational, and extended abstract. The purpose of this study was to describe the level of students' thinking in solving mathematics problems based on the SOLO taxonomy with high, medium, and low levels of mathematics anxiety. This type of research is descriptive qualitative research. This research was conducted in one of the junior high schools in Tulungagung City, East Java, Indonesia. The instruments used were a mathematics anxiety questionnaire, test based on the SOLO taxonomy, and interview guidelines. The data analysis used the Miles and Huberman model, which consists of three stages, namely data reduction, data presentation, and conclusion drawing or verification. The results showed that subjects with high mathematics anxiety had a uni-structural level of thinking. Second, subjects with moderate mathematics anxiety had a multi-structural level of thinking. Third, subjects with low mathematics anxiety have an extended abstract thinking level.*

Keywords: *Mathematics Anxiety, Mathematics Problem, SOLO Taxonomy, Thinking Level*

INTRODUCTION

Mathematics is a science that deals with abstract concepts, and these concepts relate to the nature of mathematics, namely ideas, structures, relationships that are arranged in a logical order (Rahayuningsih & Qohar, 2014). Saputro & Mampouw (2018) state that mathematics is a branch of science that is very important in human life. Rahmat (2017) states that mathematics can be used as a means to find a way out of a problem.

Ekawati et al. (2013) concluded that the thinking profile of subjects with high mathematics learning motivation was at the extended uni-structural, multi-structural, relational, and abstract thinking levels. In contrast, the thinking profile of subjects with low motivation to learn mathematics is at the level of uni-structural, multi-structural, and relational thinking. Putri dan Manoy (2013) concluded that high-ability subjects reached the uni-structural relational level, moderately capable subjects reached the uni-structural, multi-structural level and low-ability subjects reached the uni-structural level. Research by Meriyana et al. (2016) concludes that the thinking profile of subjects with high mathematics learning motivation is at the extended uni-structural, multi-structural, relational, and abstract thinking levels. In contrast, the thinking profile of subjects with low motivation to learn mathematics is at the level of uni-structural, multi-structural, and relational thinking.

Appulembang (2017) states that the first subject of impulsive cognitive style and reflective shows a tendency to solve problems at an abstract level which is extended to one-variable linear equations and two-variable linear equations. The second subject of impulsive cognitive style in problem-solving linear equations of two variables showed uni-structural and relational thinking tendencies. The second subject of reflective cognitive style showed problem-solving tendencies at the relational level. Both impulsive and reflective cognitive style subjects showed the same problem-solving tendencies at the relational level. Uni-structural, multi-structural, relational, and abstract in linear equation problems with one variable differ in level.

Widyawati, Afifah, & Resbiantoro (2018) stated that in their research, it was found that there were students with a tendency at the ultrastructural level. Subject errors at the pre-structural level tend to make mistakes in understanding questions, making plans, errors in concepts, and errors in principles. Subjects at the uni-structural level tend to make mistakes in implementing and completing plans, writing the final answer, conceptual errors, and principle errors. Subjects at the relational and extended abstract levels found no problem-solving.

A problem in mathematics is used to measure the extent to which students have achieved the expected essential competencies and train students' mindsets in using their thinking potential (Alifah & Aripin, 2018). Students' enthusiasm for learning mathematics does not match the importance of mathematics in everyday life. Based on research data, many students tend to avoid mathematics, followed by acquiring scores below 75 as much as 60%. Pratiwi et al. (2017) stated that many people or students consider mathematics difficult and even hate it. One of the difficulties students feel in mathematics is due to the ability of students themselves to solve problems or problems in mathematics.

One of the things that can cause students to experience confusion in solving problems is the difference in students' thinking levels (Kamilia et al., 2018). The level of students' thinking can be measured using taxonomy in education. According to Chan et al., 2002 SOLO taxonomy (Structure of Observed Learning Outcome) is an educational taxonomy suitable for organizing various types of learning. SOLO's taxonomy categorizes students' thinking into five levels: pre-structural, uni-structural, multi-structural, relational, and extended abstract.

In thinking, the students are influenced by several factors, one of which is anxiety. Winardi, Halini, & Hamdani (2019) stated that anxiety could inhibit students from finding facts and previous information needed in carrying out the mathematics process. This statement is also related to the inhibition of students' thinking activities, paralyzing the ability to solve even the most straightforward mathematics problems. Mathematics anxiety has a destructive impact on learning outcomes and the process of implementing mathematics learning (Anditya & Murtiyasa, 2016).

Based on the introduction above, this study aims to describe students' thinking in solving mathematics problems based on the SOLO taxonomy with high levels of mathematics anxiety. Second, describe the level of thinking of students in solving mathematics problems based on the SOLO taxonomy with a moderate level of mathematics anxiety. Third, describe the level of thinking of students in solving mathematics problems based on the SOLO taxonomy with a low level of mathematics anxiety. The condition of the Covid-19 pandemic was felt. The anxiety felt by students was increasing, afraid of the impact of Covid-19. Unreasonable situations can have a psychological impact on children.

METHOD

The type of research conducted is qualitative research. The research approach used is descriptive. The instruments used in this research are mathematics anxiety questionnaire instruments, test, and interview instruments. Test, what is meant by test here are test arranged based on the levels in the SOLO taxonomy, namely a test of mathematics problems with flat-sided space-building material. The test will be given to three subjects taken from one subject, each with high mathematics anxiety, one subject with moderate mathematics anxiety, and one subject with low mathematics anxiety. Researchers used semi-structured interviews. This interview was conducted after the subject finished doing the test based on the SOLO taxonomy to dig deeper information related to the level of thinking and the answers to the test based on the SOLO taxonomy carried out by the six subjects who had been grouped based on their level of mathematics anxiety.

This research was conducted at SMP Negeri 1 Gondang. The subjects in this study were three students from eighth-grade students who each had high, medium, and low mathematics anxiety. This type of research is descriptive qualitative research. The instruments used were a mathematics anxiety questionnaire, test based on the SOLO taxonomy, and interview guidelines. Data collection techniques include questionnaires, tests, and interviews. Meanwhile, the data were analyzed using the Miles and Huberman model, namely data reduction, presentation, and conclusion. The data analysis used by researchers in managing data in this study refers to the Miles and Huberman model (Sugiyono, 2012), which consists of three stages, namely data reduction, data presentation, conclusion drawing/verification.

Table 1. Scoring for Mathematics Anxiety Questionnaire

Category	Score
Strongly Agree	4
Agree	3
Disagree	2
Strongly Disagree	1

Table 2. Criteria of Students' Mathematics Anxiety Levels

Score	Mathematics Anxiety Level
Score ≥ Mean + SD	High
Mean – SD < Score < Mean + SD	Medium
Score < Mean – SD	Low

FINDINGS

The questionnaire was given in the form of a google form due to the Covid-19 pandemic conditions, making it impossible to meet face to face. The results of grouping mathematics anxiety levels can be seen in Table 3.

Table 3. Category of Mathematics Anxiety Levels

Students' Codes	Score	Category
ST1	30	High
ST2	30	High
ST3	28	High
ST4	28	High
SS1	26	Medium
SS2	26	Medium
SS3	25	Medium
SS4	25	Medium
SS5	25	Medium
SS6	25	Medium
SS7	24	Medium
SS8	23	Medium
SS9	22	Medium
SS10	22	Medium
SS11	22	Medium
SS12	22	Medium
SS13	22	Medium
SS14	21	Medium
SS15	21	Medium
SS16	20	Medium
SS17	20	Medium
SS18	19	Medium
SS19	19	Medium
SS20	19	Medium
SR1	18	Low
SR2	17	Low

From table 1 above, the red row column is the subject with high anxiety, the yellow row column is the subject with moderate anxiety, and the green row column is the subject with low anxiety. In this study, researchers took three research subjects who had a high level of anxiety assessed from the attitude during the interview. One subject with high mathematics anxiety, one subject with moderate mathematics anxiety, one subject with low mathematics anxiety. Subjects that represent high anxiety ST3, moderate anxiety SS14, and low anxiety SR1.

DISCUSSION

Thinking Level of Students' with High Anxiety

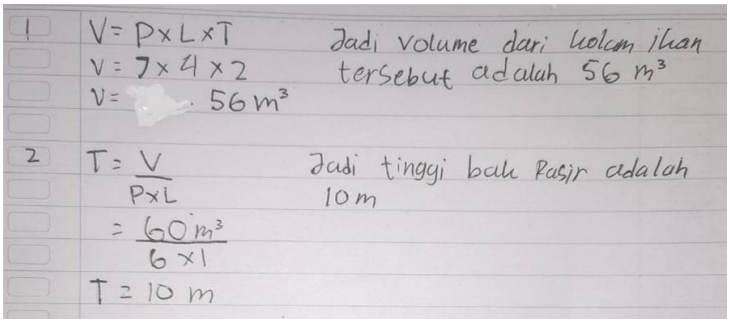

Figure 1. ST3 Answer

The ST3 subjects were able to solve the uni-structural level questions and understand them, but the subjects did not write down what they knew and were asked in the questions. The subjects could solve the uni-structural questions and write the final answers correctly. Based on the unstructured level indicator, the subject can use the information on the question to find the correct answer. The subject can also conclude from the information to find the correct answer. The subjects focus on finding the concept of the volume of a cuboid only and do not use other concepts besides that on the uni-structural level questions. Students are only required to think at a basic level, namely by looking for the volume of cuboids that can be solved well by the ST3 subject. This fact is in line with what was expressed by Meriyana et al. (2016), which states that at the uni-structural level, the subject of thinking focuses on only one concept without making connections between one concept and another. The subject shows how to think at a basic level and identify basic facts.

On multi-structural level questions, the subject wrote the wrong final answer. This problem was caused because the subject was unable to correctly understand information about the cuboid's width, which resulted in the subject being wrong in writing the final result. This problem happened because of high mathematics anxiety on the subject, so that the subject could not understand the information on the problem correctly. This fact is in line with what was stated by Auliya (2018), which states that students with high mathematics anxiety tend to be less confident in understanding mathematics concepts. Therefore, mathematics anxiety must be overcome to develop better mathematics understanding abilities. Apriliani & Suyitno (2016) also revealed that high mathematics anxiety could cause students to be weak in calculations, lack understanding, and lack initiative in finding strategies and relationships between mathematics domains. Mathematics anxiety makes the subject wrong in writing the final answer on the multi-structural level question. From the explanation above, it can be concluded that the ST3 subject with high mathematics anxiety has a uni-structural level of thinking.

Thinking Level of Students' with Medium Anxiety

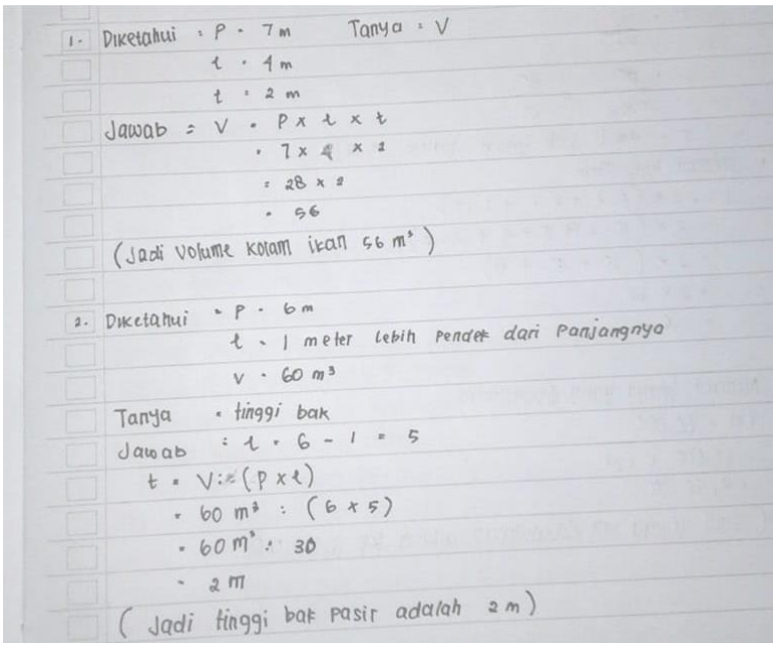

Figure 2. SS14 Answer

SS14 subjects can solve uni-structural level questions and understand the questions. The subject writes down what is known and is asked in the questions. The subject can solve the uni-structural questions and write the final answer correctly. Based on the unstructured level indicator, the subject can use the information on the question to find the correct answer. The subject can also conclude from the information to find the correct answer. Subjects focus on finding the concept of the volume of cuboids and do not use other concepts besides that on the uni-structural level questions. Students are only required to think at a basic level, namely by finding the volume of cuboids that can be solved well by the SS14 subject. This fact is in line with Meriyana et al. (2016).

At the multi-structural level question, SS14 understands what is being asked. The subject can also state what information on the question. The subject answers the question by guessing and experimenting first. Although, at first, the subject was confused and unsure, in the end, the subject knew how to find the width of the cuboid and gave the correct final answer. Based on multi-structural level indicators, the subject can use several pieces of information that are not linked together, namely by understanding the cuboid width information implied in the question and then linking the information together and finding the correct final answer. Subjects are also able to conclude from two or more information. The subject finds a conceptual relationship in the problem, which is about finding a height. It can be calculated by dividing the known volume of the cuboid by the multiplication of length and width of the cuboid. Other information on the problem about the width of the cuboid, which is one meter shorter than the length, can also be understood well by the subject SS14. It is in line with Meriyana et al. (2016) expressed that subjects at the multi-structural level used some information to produce answers. It shows that the subject understands the relationship between several concepts. The relationship can be traced by applying simple arithmetic operations.

The subject only solves questions to the multi-structural level and does not work on the relational level, and extends abstract level questions. It is because the subject has moderate mathematics anxiety. The subject feels that the relational level and extended abstract questions are a problem and a threat because they cannot solve them, so the subject chooses to avoid them or not do them. By what was expressed by Widaninggar et al. (2017), anxiety is a signal that awakens, warns, of a danger that threatens and allows a person to take action to overcome the threat. Anxiety is awareness of overcoming threats in dealing with mathematics problems. So, the subject with anxiety chooses to overcome the threat by not doing the next level question. From the explanation above, it can be concluded that the SS14 subject with moderate mathematics anxiety has a multi-structural level of thinking.

Thinking Level of Students' with Low Anxiety

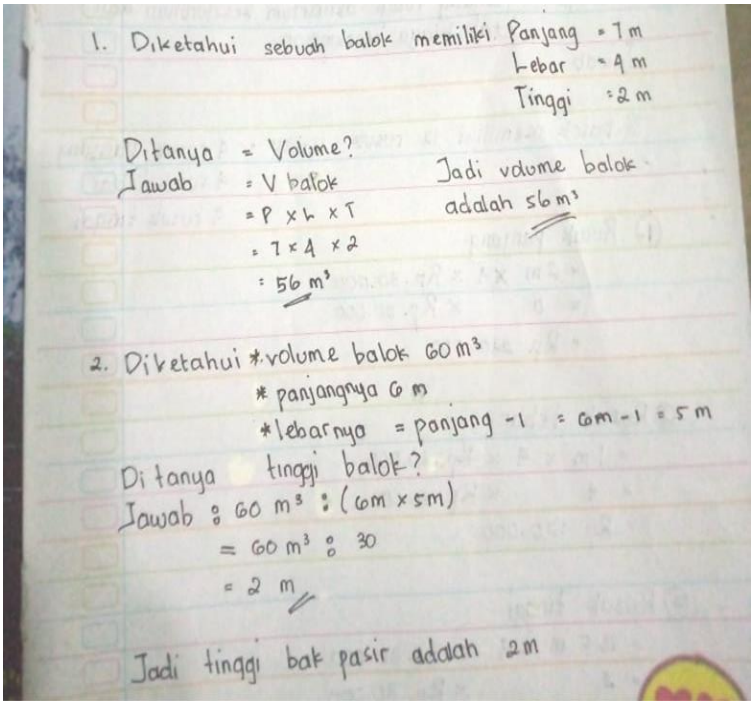

Figure 3. SR1 Answer

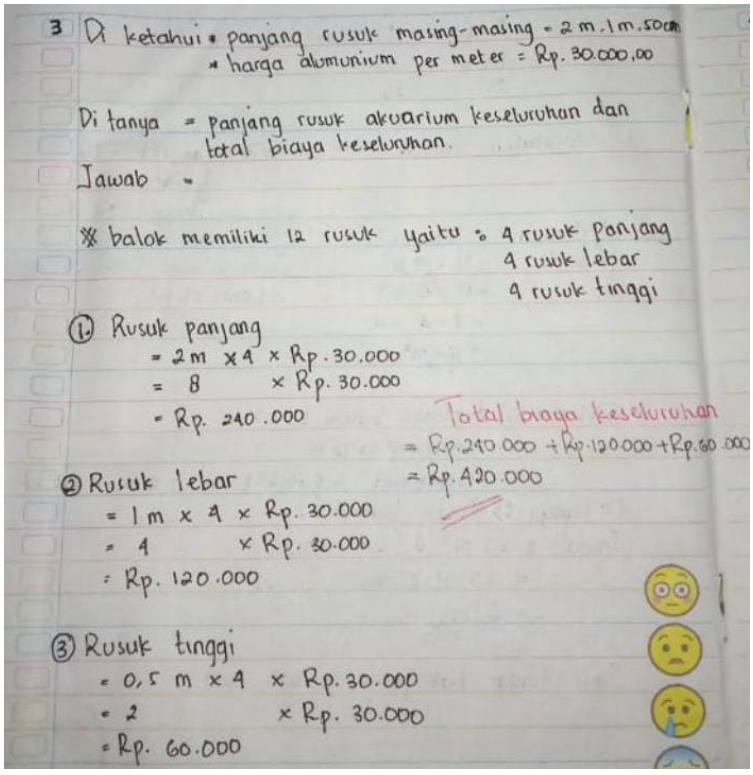

Figure 4. SR1 Answers

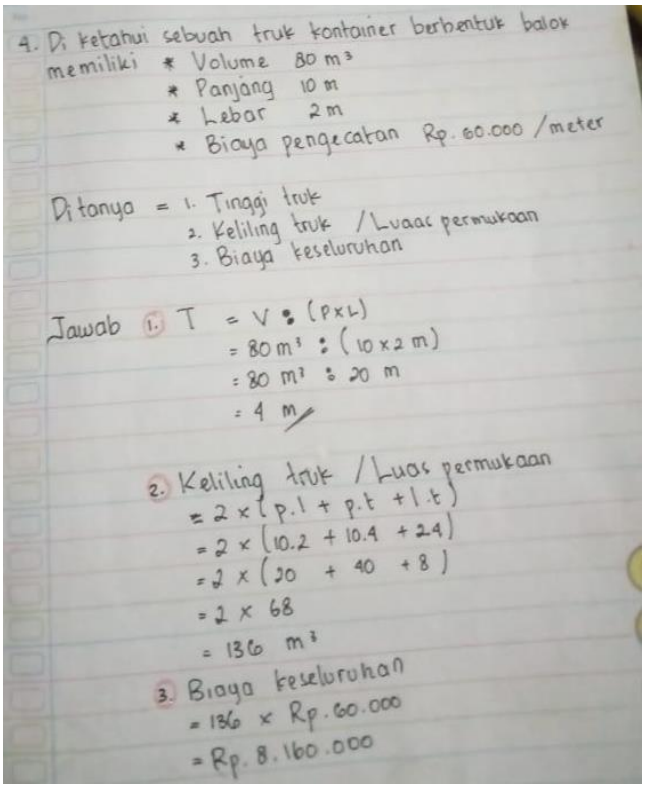

Figure 5. SR1 Answer

SR1 subjects can solve uni-structural level questions and understand questions. Subjects write down what they know and are asked in the questions. The subject can solve the uni-structural questions and write the final answer correctly. Based on the unstructured level indicator, the subject can use the information on the question to find the correct answer. The subject can also conclude from the information to find the correct answer. Subjects focus on finding the concept of the volume of cuboids and do not use other concepts besides that on the uni-structural level questions. Students are only required to think at a basic level, namely by finding the volume of cuboids that can be solved well by the SS14 subject. It is in line with Meriyana et al. (2016).

On multi-structural level questions, the SR1 understands what is being asked in the question. The subject can also state what information on the question. The subject is very confident in explaining the question. The subject writes the correct final answer. Based on multi-structural level indicators, the subject can use several pieces of information that are not linked together, namely by understanding the cuboid width information implied in the question and then linking the information together and finding the correct final answer. Subjects are also able to conclude from two or more information. The subject finds a conceptual relationship in that problem about finding height that can be calculated by dividing the known volume of the cuboid by the multiplication of length and width of the cuboid. Other information on the problem about the width of the cuboid, which is one meter shorter than the length, can also be understood well by the subject SS14. It is in line with what was expressed by Meriyana et al. (2016).

At the relational level, the SR1 understands what is being asked in the question. The subject can also state what information on the question. The subject is very confident in explaining the question. The subject writes the correct final answer. Based on the relational level indicator, the subject can combine separate pieces of information, namely about the cuboid ribs and the cost per meter. The subject can also conclude from the information because the information in the question

is separated, and the subject writes the correct final result. This finding was expressed by Meriyana et al. (2016), subjects at the relational level integrate several concepts to form more complex concepts based on recognized numerical patterns. It is associated with the opinion of Widyawati, Afifah, Resbiantoro (2018), explaining that in working on relational items, the subject must understand several conceptually integrated components and break a whole into parts and determine how the parts are connected with several models.

At the extend abstract level, the SR1 understands what is being asked in the question. The subject can also state what information on the question. The subject is very confident in explaining the question. The subject writes the correct final answer. Based on the extend abstract level indicator, the subject can produce general principles from integrated data, and also the subject can compile general principles based on the information provided and apply it to new situations, namely when the subject can calculate the cuboid height from the information provided by the question after that the subject can use the cuboid height. Found in the new situation, namely finding the surface area of the cuboid. After that, the subject can calculate the total cost needed on the matter. Subjects are also able to write down the correct final result. Hasan (2017) stated that students use all data/information at this level, then apply concepts/processes, provide quick results, and connect them with other data or processes to draw relevant conclusions and make generalizations from the results obtained. Students think conceptually and generalize to a domain/area of knowledge and other experiences.

SR1 subjects with low mathematics anxiety can solve all levels of questions well. This fact aligns with what Auliya (2018) expressed that students who excel have high anxiety levels. From the explanation above, it can be concluded that the SR1 subject with low mathematics anxiety has an extended abstract thinking level.

CONCLUSIONS

Based on the findings and analysis of the researchers, the level of thinking of students in solving mathematics problems based on the Solo taxonomy with high, medium, low anxiety can be concluded as follows. First, subjects with high mathematics anxiety have a uni-structural level of thinking. In addition, a subject with mathematics anxiety has multi-structural level thinking. Third, subjects with low mathematics anxiety have an extended abstract thinking level.

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