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PISA-BASED PROBLEM-SOLVING ABILITY OF QUANTITY CONTENT BASED ON SOLO TAXONOMY IN TERMS OF NUMERACY ABILITY

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Abstract

An essential aspect that needs to be considered in learning mathematics is the ability to solve problems because it can be helpful in many fields of study and real life. This ability has a close relationship with students' numeracy ability. In measuring the quality of students' responses when solving math problems such as the PISA quantity content, the Structure of the Observed Learning Outcome (SOLO) taxonomy can be used as an effective evaluation tool. This study aims to examine the ability of PISA-based problem-solving on quantity content based on SOLO taxonomy in terms of numeracy ability. This research is descriptive with a qualitative approach and was conducted at Muhammadiyah Middle School Special Program Kottabarat Surakarta in the odd semester of the 2024/2025 academic year, with the subject of class IX students. Data were collected through tests and interviews using instruments such as numeracy tests, PISA problem-solving tests on quantity content, and interview guidelines. Data analysis was conducted through three stages: data reduction, displaying data, and data verification. The results showed that the PISA-based problem-solving ability of students with high numeracy ability reached the uni-structural level. Students with medium numeracy ability reached the multi-structural level, and students with high numeracy ability reached the relational level in SOLO taxonomy.

Keywords: numeracy ability, PISA, problem-solving ability, SOLO taxonomy

Abstrak

Aspek esensial yang perlu diperhatikan dalam pembelajaran matematika adalah kemampuan pemecahan masalah, karena dapat berguna di banyak bidang studi dan di kehidupan nyata. Kemampuan ini memiliki hubungan yang erat terhadap kemampuan numerasi yang dimiliki siswa. Dalam mengukur seberapa baik kualitas respon siswa saat memecahkan permasalahan matematika seperti pada persoalan PISA konten quantity tersebut, taksonomi Structure of the Observed Learning Outcome (SOLO) dapat digunakan sebagai alat evaluasi yang efektif. Tujuan dari penelitian ini untuk mengkaji kemampuan pemecahan masalah berbasis PISA konten quantity berdasarkan taksonomi SOLO ditinjau dari kemampuan numerasi. Penelitian ini bersifat deskriptif dengan pendekatan kualitatif dan dilaksanakan di SMP Muhammadiyah Program Khusus Kottabarat Surakarta pada semester ganjil tahun pelajaran 2024/2025, dengan subjek siswa kelas IX. Data dikumpulkan melalui tes dan wawancara, menggunakan instrumen berupa tes numerasi, tes pemecahan masalah PISA konten quantity, dan pedoman wawancara. Analisis data dilakukan melalui tiga tahap: reduksi data, penyajian data, dan penarikan kesimpulan. Hasil penelitian menunjukkan bahwa kemampuan pemecahan masalah berbasis PISA konten quantity pada siswa dengan kemampuan numerasi tinggi mencapai level unistruktural. Siswa dengan kemampuan numerasi sedang mencapai level multistruktural, dan siswa kemampuan numerasi tinggi mencapai level relasional dalam taksonomi SOLO.

Kata kunci: kemampuan numerasi, kemampuan pemecahan masalah, PISA, taksonomi SOLO

INTRODUCTION

Problem-solving ability is one of the essential skills in the current era that is needed to face complex challenges in various aspects of life. This ability is the basic thing a person must have when learning mathematics, so it is not surprising that it is considered the heart

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of mathematics. According to Ruseffendi in Hetty Marhaeni (2021), problem-solving ability is very important not only for someone who plans to deepen mathematics in the future but also for someone who applies it in various other fields of study and everyday life. It is also emphasized based on NCTM that in mathematics, students must meet a standard process, including problem-solving (Aulia & Murtiyasa, 2023). In mathematics, problem-solving ability, according to the statements Andayani & Lathifah (2019) and Meilia Asmara & Puspaningtyas (2023), the potential to solve story problems, problems that are not routinely given, and the application of mathematics in everyday life to find a solution or solution to the issues that exist in mathematics owned by someone. Problem-solving itself means a series of procedures where someone who does not yet know the solution to the problem performs a combination of the knowledge they have (Setyaningsih et al., 2018). Therefore, this ability is something that students must possess because, basically, it can be a provision in overcoming challenges and improving mathematical skills that are useful in real life.

PISA (Programme for International Student Assessment) is an international standard program held by the OECD (Organization for Economic Cooperation and Development) every three years made for students aged 15 years to see the extent of the level of knowledge and skills possessed in solving mathematical problems in everyday life towards the end of compulsory education (OECD, 2018). This aligns with the opinion that PISA measures students' ability to use mathematical concepts in everyday life (Febriyani & Setyaningsih, 2024). The program, attended by more than 70 countries, including Indonesia, can be a benchmark for comparing student achievement between participating countries. PISA is a study that assesses the quality of a country's education system through ability tests, namely reading, math, and science (Suminar & Rahman, 2022). In reality, the mathematics ability in Indonesia is not optimal or is still said to be low compared to other more developed countries, even in the bottom ten positions. This is evidenced by the results of the Indonesian PISA study in 2006, ranked 50 out of 57 countries; in 2009, ranked 57 out of 65 countries; in 2012, ranked 64 out of 65; in 2015, ranked 62 out of 70 countries; and in 2018 ranked 74 out of 79 countries (Zahro & Haerudin, 2022).

Based on an interview with one of the ninth-grade math teachers, it was found that students' problem-solving abilities in dealing with story-shaped problems such as PISA are still poor. Low literacy culture is the leading cause of the lack of students' problem-solving ability. This aligns with the research results of Febrianti & Nurjanah (2022), which state that these difficulties occur due to students' low understanding of the material taught, difficulty interpreting, and low mathematical literacy skills. Students tend to dislike and are not familiar with these types of problems because they have to read and understand the problems repeatedly before they can solve them. In contrast, they are more comfortable and able to work on problems where the information is known immediately without further interpretation. In solving PISA problems, students must be able to read, understand, explain arguments, and apply mathematical concepts, steps, and facts (Pereira et al., 2022).

Based on the PISA content classification, one is the quantity content, which relates to the subject matter of numbers and number patterns. It is not only about performing calculation operations but also the ability to reason quantitatively, present things in numbers, know mathematical procedures, and use counting outside the head and estimating. Understanding the quantity content is fundamental because it can affect the sub-materials in other content. This follows the statement of Murtiyasa (2015) that quantity content is the primary method for describing and measuring various objects, including testing relationships and changes, organizing and interpreting data, and measuring and assessing uncertainty.

In solving PISA problems on quantity content, it is also necessary to consider the numeracy ability of students at different levels. Numeracy abilities are very necessary for students because these skills have a close relationship with the ability to solve math problems in everyday life (Tyas & Pangesti, 2018). Students with good numeracy abilities will be able to handle challenges and solve math problems effectively. Vice versa, students with poor numeracy abilities will have difficulty solving math problems. The ability of students to solve problems cannot be directly identified by the teacher based on the thinking process that occurs but can be known from the quality of students' responses to a mathematical problem (Faisal & Maryulianty, 2019). Based on this, a tool is needed that can measure how good the quality of student responses is in solving math problems, such as the PISA problem on quantity content, one of which uses the SOLO (Structure of the Observed Learning Outcome) taxonomy.

SOLO taxonomy is a special classification that identifies the quality level of learning outcomes, reviews student responses, and identifies types of errors in problem-solving. This taxonomy is an effective and systematic evaluation tool to help teachers assess the extent of student's understanding of a problem based on the level of complexity of understanding when solving math problems. The purpose of the SOLO taxonomy is to provide systematic steps in analyzing students' structural development when facing a problem (Kuswana in Silwana et al., 2021). In measuring students' ability to respond to a problem, SOLO taxonomy is classified based on five hierarchical levels: pre-structural, uni-structural, multi-structural, relational, and extended abstract levels (Azmia & Soro, 2021; Maulidia et al., 2019; Umardiyah & Nasrulloh, 2021).

Based on this description, to find out the extent of PISA-based problem-solving ability, the researcher will examine the ability of PISA-based problem-solving on quantity content based on SOLO taxonomy in terms of numeracy ability.

METHODS

This research type is descriptive with a qualitative approach because it aims to describe in depth the phenomena that occur based on natural conditions.

This research took place at Muhammadiyah Middle School Special Program Kottabarat Surakarta. It was carried out in the odd semester of the 2024/2025 academic year, and the research subjects were 31 students of class IX.

The data collection techniques used in the study were tests and interviews. The test was conducted to determine the problem-solving ability based on SOLO taxonomy. The test was in the form of PISA questions on quantity content and validated student numeracy tests. This study has two stages; the first is giving numeracy test questions in the form of multiple choice questions totaling 15. Based on the test, students were classified into students with low, medium, and high numeracy abilities based on the following classification:

Table 1. Classification of Numeracy Ability

Value Interval	Category
80 ≤ score ≤ 100	High
65 ≤ score ≤ 80	Medium
0 ≤ score ≤ 65	Low

The second stage is the provision of PISA-based questions on quantity content in the form of essay questions (descriptions) that meet the criteria of the questions. In collecting data, the interview method is carried out through question-and-answer interaction between the interviewer and the source of information to obtain in-depth information. Researchers conducted interviews with several selected students to strengthen the data presented from the test results and receive more in-depth information related to the problems studied. The following are the PISA-based test questions on quantity content on number pattern material:

A tutoring institution monitors the growth of enrollment every year. In the first year, the number of applicants was 100 students; in the second year, it increased to 125 students; in the third year to 150 students; and in the fourth year to 175 students, with an increase of 25 students each year. The institution targets a total enrollment of 2260 students within ten years. Can this target be achieved with the current pattern of increase? If not, how much of an increase in enrollment needs to be implemented each year to reach the target?

The data analysis technique of this study uses stages that adapt from Miles and Huberman, namely data reduction, displaying data, and data verification (Tresnasih et al., 2022). Data reduction is done by analyzing test answers to mathematical problems that students have done. It is conducting a process of selecting, centering, simplifying, and abstracting various information that supports research data (Triningsih et al., 2024). Data will be presented by identifying the type of students' problem-solving ability in solving PISA-based problems on quantity content based on SOLO taxonomy. The last stage is by drawing conclusions and verifying based on the collected and processed data to obtain conclusions about the ability of PISA-based problem solving on quantity content based on SOLO taxonomy in terms of numeracy ability. The following are indicators of SOLO taxonomy levels:

Table 2. Level Indicators in the SOLO Taxonomy

Level	Indicator
Pre-structural	• Students do not understand the information in the question • Students ignore important information or use irrelevant information • Problem-solving is not related to the given problem • The student's answer does not form any concept and has no meaning in the context of problem-solving
Uni-structural	• Students can understand important information from the problem • Students can apply only one piece of relevant information to solve the problem • The student's answer shows limited understanding and does not consider other relevant information • Students' inferences are simple or irrelevant

Multi-structural	• Students can recognize and use some relevant information or concepts in the problem • Students can apply some pieces of information but are not able to / not perfect in linking the information, so it does not form a comprehensive understanding • Students' inference is still limited and inappropriate
Relational	• Students show a thorough understanding of the problem information given • Students can connect several relevant concepts or information logically in problem-solving • Students can solve problems with the right solution • Students can draw relevant conclusions • Students show the ability to think critically but have not been able to generalize concepts broadly
Extended Abstract	• Students can apply all the information in the problem effectively • Students can relate some information to find the correct answer • Students can draw relevant and accurate conclusions from the information provided • Students can make generalizations for application to broader contexts or new problems

RESULTS AND DISCUSSION

Based on the research data results carried out at Muhammadiyah Middle School Special Program Kottabarat Surakarta in the first test to test numeracy ability to 31 students. The following is the distribution of many students based on the numeracy ability category seen from the test scores:

Table 3. Classification of Test Score Categories

Numeracy Ability Category	Many Students
High	12 Students
Medium	13 Students
Low	6 Students

After the classification of student categories based on the test scores in Table 3, one student from each category of mathematical ability (low, medium, and high) was selected as a research subject and retested on the second test, namely the PISA-based question on quantity content. Each research subject was coded as S1 for students with low numeracy ability, S2 for students with medium numeracy ability, and S3 for students with high numeracy ability.

The results of the three students' work from the second test were analyzed based on the PISA problem-solving ability of quantity content to be classified into SOLO taxonomy levels. By using SOLO taxonomy, each student's answer was evaluated to determine the level of complexity and depth of their understanding, from pre-structural to extended abstract levels, according to the indicators in Table 2. The following is an analysis of the ability of PISA-based problem solving on quantity content based on SOLO taxonomy in terms of numeracy ability:

Students with Low Numeracy Ability (S1)

The following is the result of the answer by S1:

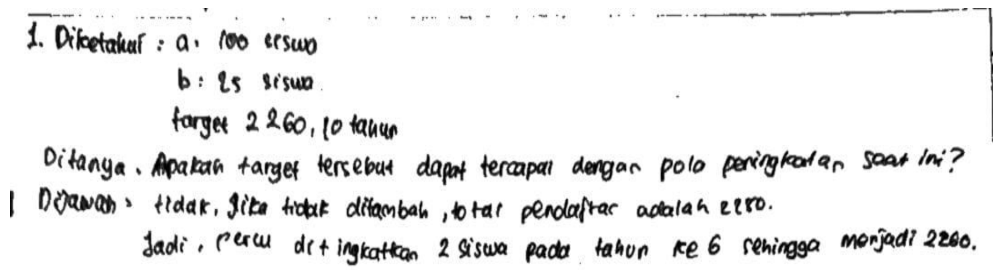


Figure 1. S1's Answer

Results of interview with S1:

P	:	*Tell me what's in the problem!*
S1	:	*The total number of registrants, for which "a" is 100 students, 25 apart according to the pattern in 10 years, is 2260. The question is how much the number of registrants will increase to reach the target. My answer is two, starting from the sixth year because there are five years left, so two years, I think so*
P	:	*What formula do you use to solve the problem??*
S1	:	*I don't use the formula; I use reasoning*
P	:	*What steps did you use to come up with the final answer?*
S1	:	*At first, I looked for the total for all ten years according to the pattern 25, 25 totals 2250, so the lack of 10, so I added 2 for the year*
P	:	*So, what can you conclude from your answer?*
S1	:	*So, starting from the sixth year, the addition of 27 students*

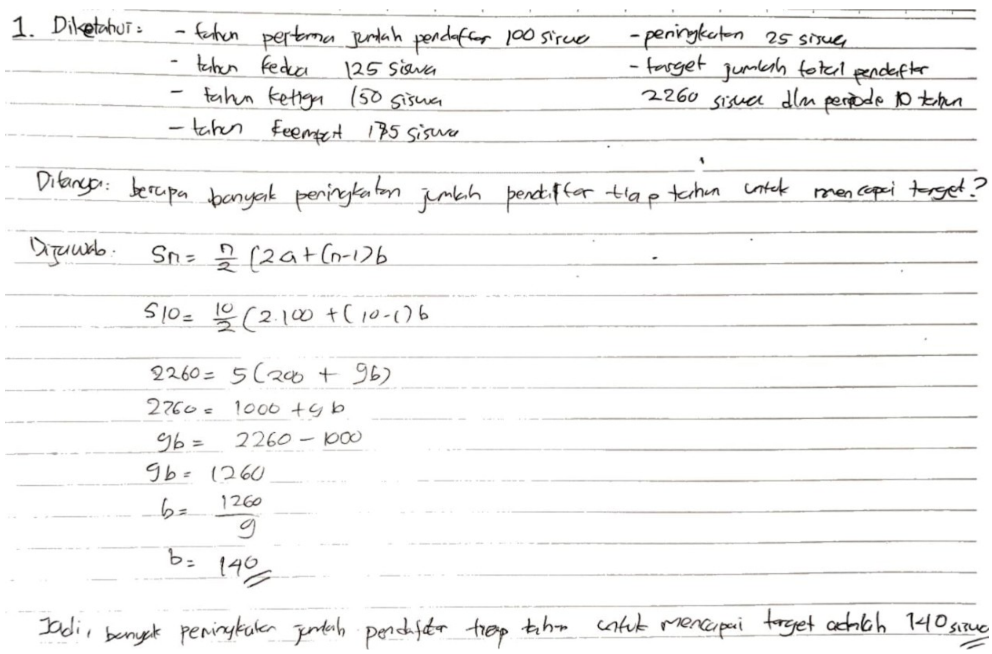
In Figure 1, It can be seen that S1 knows and understands the information in the problem by writing what is known, namely students and students, and writing what is asked in the question, namely whether the target can be achieved with the current improvement pattern. This is confirmed by the interview results that they can understand important information from the PISA questions with quantity content.

In the process of problem-solving, S1 does not use existing methods or formulas but applies logical reasoning by using the difference to find the total for ten years according to the pattern. That way, S1 applied one relevant piece of information, namely the use of difference in solving the problem. Nevertheless, the calculation was still wrong, which resulted in the answer of the total enrollment of 2,250 students, which should be 2125 students. This means that S1 showed limited understanding and did not consider other relevant information.

Incorrect calculations can impact the final answer and even lead to wrong conclusions. There is a conclusion that the target was not achieved, but they do not know the completion process to reach the stated conclusion. S1 concluded that it was necessary to increase two students in the 6th year, namely to 27 students, which should increase enrollment by 28. This shows that S1 has not been able to conclude correctly. Based on the analysis of problem-solving abilities, S1 reached the uni-structural level indicator in the SOLO taxonomy.

Students with Medium Numeracy Ability (S2)

The following is the result of the answer by S2:



1. Diketahui: - tahun pertama jumlah pendaftar 100 siswa - peningkatan 25 siswa
- tahun kedua 125 siswa - target jumlah total pendaftar
- tahun ketiga 150 siswa 2260 siswa dlm periode 10 tahun
- tahun keempat 175 siswa

Ditanya: berapa banyak peningkatan jumlah pendaftar tiap tahun untuk mencapai target?

Dijawab: $Sn = \frac{n}{2}(2a+(n-1)b$

$S10 = \frac{10}{2}(2.100+(10-1)b$

$2260 = 5(200+9b)$

$2260 = 1000+9b$

$9b = 2260-1000$

$9b = 1260$

$b = \frac{1260}{9}$

$b = 140$

Jadi, banyak peningkatan jumlah pendaftar tiap tahun untuk mencapai target adalah 140 siswa

Figure 2. S2's Answer

Interview results with S2:

P	:	*Tell me what information is in the question!*
S1	:	*What is known is the number of registrants each year; in the first year, there were 100 students; in the second year, there were 125 students; in the third year, there were 150 students, meaning an increase of 25. What is asked is how much the increase in the number of registrants needs to*
P	:	*What was the first step you took to solve the problem?*
S1	:	*The first is whether the target has been achieved with the 25 pattern, right, first search, then search, eh it turns out it's not, then search for it using Sn.*
P	:	*Yes, then how come you can get 9b, 5 × 9b how much?*
S1	:	*Oh, 45b, right?*
P	:	*Yes, so the calculation is wrong. Actually, the method is correct, so what is the conclusion if the b is 28?*
S1	:	*So, if the target was not achieved in the previous pattern, continue using the new pattern to achieve it*

In Figure 2, It can be seen 2 that S2 knows and understands the information contained in the problem by writing what is known (the number of registrants each year) and what is asked (the number of registrants that need to be increased to reach the target). The results of the interview S2 can also include all the information about the problem correctly.

In the problem-solving process, S2 can plan the strategy well using the formula (the number in 10 years) to get the difference (the increase in the number of registrants each year to reach the target). That way, S2 can apply several pieces of information and link them together to form a comprehensive understanding of how to solve the problem. However, when applying the strategy, there were still errors in the calculation. This is due to the lack of accuracy in the multiplication operation in parentheses, especially in the calculation part of the problem , where the result obtained should be . S2 has confirmed the error through interviews. This can affect the final result and conclusion of problem-solving so that S2's answer is incorrect. Based on the problem-solving ability analysis, S2 reached the multi-structural level indicator in SOLO taxonomy.

Students with High Numeracy Ability (S3)

The following is the result of the answer by S3:

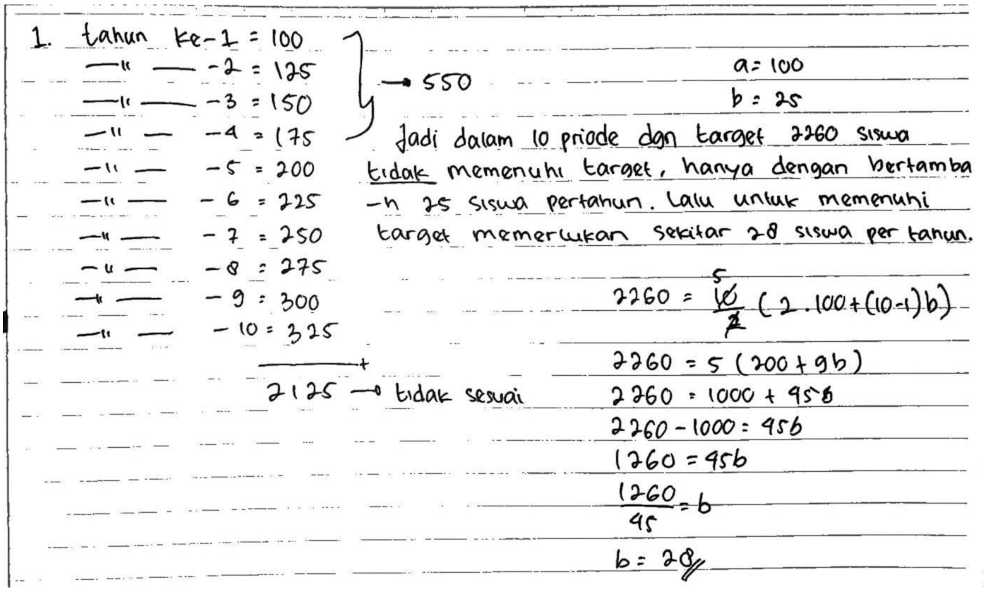


Figure 3. S3's Answer

Interview results with S3:

P	:	*Tell me what information you took from this problem!*
S3	:	*In the first year, 100 students are taken. That's every increase of 25 students means b, the target to be achieved in 10 years is 2260*
P	:	*What is the question of the question?*
S3	:	*I forgot to write it there. What was asked was whether the target target of 2260 registrants in 10 years using the current pattern has been achieved. If not, how many registrants must be added each year to achieve the target?*
P	:	*What formula did you use?*
S	:	*Use the formula Sn ma'am*
p	:	*Explain the steps you have taken to get the final answer!*
S3	:	*The tutor has a target of 10 years. We first try to reach it, but it turns out that it doesn't work. Then, we have to find another pattern to increase the capacity so that it has to be 2260*
P	:	*So how did it go?*
S	:	*This means the increase is 28*
P	:	*What is the conclusion?*
TI	:	*So, the first pattern could not reach the target; 28 were needed to achieve the target*

In the answer in Figure 3, it can be analyzed that S3 students know and understand the information by writing what is known in the problem, namely and , but they did not write down what the question contained in the problem. In the interview, it was revealed that S3 actually knew what was asked in the question but forgot to write it down. This shows a thorough understanding of the problem information given.

S3 can carry out its strategy in a structured manner by starting with the verification step to prove that the pattern of registrants in the previous period, which includes the first ten weeks, has not been able to reach the target that has been set. S3 calculates the total registrants in the period by adding up the number of registrants from each week, and the result is 2125 registrants. Furthermore, S3 used the formula to find the difference (many increases in the number of registrants each year to achieve the target) by substituting (10-year period) and (the number of registrants in the first year). This shows that S3 is able to connect several relevant concepts or information, such as the use of arithmetic series, and apply them logically in problem-solving. In addition, it can produce the right solution, namely obtained . S3 can also conclude the PISA problem with the correct quantity content. S3 can answer interview questions correctly and firmly on the results of the answers that have been written down. However, S3 has not been able to generalize the concept widely. That way, S3 can reach the relational level in the SOLO taxonomy.

Based on the explanation above, it can be seen that the ability to solve PISA problem-solving on quantity content based on SOLO taxonomy for students with low numeracy ability reaches the uni-structural level, students with medium numeracy ability reach the multi-structural level, and students with high numeracy ability reach the relational level.

The problem-solving ability of students with low numeracy ability is at the uni-structural level of SOLO taxonomy. Students at this level can identify important information contained in the problem well, but not with the steps to implement the problem-solving strategy. In line with this, Santoso & Setyaningsih (2020) mentioned that a student with low mathematical ability can understand the problem but cannot find the right solution concept to answer a problem. At the uni-structural level, it only answers the problem in a limited way by applying only one piece of relevant information to the problem, but the answer given still shows limited understanding and does not consider other relevant information, so it does get the right answer. Drawing conclusions that are still simple or not appropriate. This is in line with the opinion of Dardianto Arico & Wahyudi (2021) that uni-structural means only focusing on one or several important pieces of information available to provide a response to a concrete problem that is directly related so that a quick conclusion can be reached on minimal use of existing information. This is also corroborated by research conducted by Mega et al. (2023), namely, students who are at the uni-structural level can understand the problem so that they understand what is known and asked, although they still make conceptual errors, enter data, and draw conclusions. Students at the uni-structural level are only able to use one piece of information in problem-solving (Wulansari et al., 2020).

The problem-solving ability of students with moderate numeracy ability is at the multi-structural level of SOLO taxonomy. At this level, students can recognize and use some critical information or relevant concepts from problems, such as what is known and asked. In solving problems, students can apply several pieces of information and relate them to form a comprehensive understanding but still cannot get the correct final result. Due to calculation errors, it is still impossible to draw the correct conclusion. Wea & Saputro (2024) state that students who know the information from the problem and can write the formula used but still have errors in calculation operations are included at the multi-structural level. This is also corroborated by research conducted by Novitasari & Wilujeng (2018), which found that students with moderate ability do not understand calculation operations, so errors occur, which result in incorrect answers.

The problem-solving abilities of students with high numeracy abilities are at the relational level of the SOLO taxonomy. In solving problems, students show a thorough understanding of important information. Students can link several relevant pieces of information logically. Students can solve problems with the right solution. The relational level can be characterized by the ability of students to predict problem-solving from what is known by linking two pieces of information and solving it (Authary & Nazariah, 2019).

In addition, students with high numeracy ability can draw relevant conclusions from the problem. In line with research conducted by Febiyanti et al. (2020), students at the relational level can understand facts with theories as well as actions and goals so that no errors are found in the problem-solving process. However, even though students are already at the relational level, they still show limitations in generalizing concepts broadly. Concept generalization involves abstracting ideas or principles from specific situations and applying them in various new contexts or problems. Students at this stage may still tend to think in a particular scope and have not fully developed the ability to see general patterns or principles that can be applied outside the context of the problem at hand. With further development in generalization ability, students can have the potential to achieve higher levels of understanding and broader and more flexible problem-solving abilities.

The explanation above shows that there are different levels of SOLO taxonomy in terms of numeracy ability. In high numeracy ability, the way students think is at the relational level, which allows students to link various information logically and thoroughly to produce the right solution and draw relevant conclusions from the given problem. Meanwhile, the way of thinking of students with medium numeracy ability is at the multi-structural level, where students can recognize and use some important information. Still, there are often errors in the calculation process, which results in inappropriate conclusions. Furthermore, the way of thinking of students with low numeracy ability is at the uni-structural level, where students can only identify one important piece of information without linking it to other information, so their problem-solving results are limited and less accurate.

CONCLUSION

Based on the results of the discussion, it can be concluded that the problem-solving ability of PISA content quantity in class IX students of Muhammadiyah Middle School Special Program Kottabarat Surakarta in terms of high, medium, and low numeracy abilities can be identified so that different levels of SOLO taxonomy can be achieved. The problem-solving ability of students with low numeracy can only reach the uni-structural level in SOLO taxonomy. The problem-solving ability of students with medium numeracy reaches the multi-structural level of SOLO taxonomy. The problem-solving ability of students with high numeracy ability reaches the relational level of SOLO taxonomy. Thus, the higher the numeracy ability of a student, the higher the level of SOLO taxonomy that can be achieved. Better numeracy allows students to process information more in-depth and complexly, connect various concepts, and solve problems more effectively and accurately. Conversely, students with lower numeracy ability tend to have more limited understanding and are at a lower level in the SOLO taxonomy.

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