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Mathematical Representation Ability-Based Mathematical Contextual Problems of Sequences and Progression Material

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ABSTRACT

This research objective is to analyze and explain the student's capacity for mathematical representation based on mathematical contextual problems of arithmetic and geometric sequences and progression material. Students enrolled in SMA 1 Sukoharjo X.E10 were the subject of this research. The data collection process used interviews, tests, and documentation. This research used a descriptive research approach with a qualitative research type. Based on the findings of this research, students who have visual representation skills in mathematics are more likely to complete challenges that involve visuals, such as diagrams. Typically, mathematically symbolic representation-capable pupils utilize mathematical formulas and symbols to solve problems. Furthermore, students who have the ability to verbally represent mathematics have a tendency to encrypt problem-solving steps into words.

1. Introduction

Indonesian mathematical ability is still not optimal. According to (OECD, 2023:426), the average math score in PISA 2022 was 366, which fell by 13 points compared to the average math score in PISA 2018. In addition, a study from TIMMS in 2015 showed that Indonesia's average math score was 397, ranking 44 out of 49 countries, with the average score of the whole country being 500 (Mullis et al., 2016). This shows that Indonesia's average math score is still below the international average. Mathematics is one of the most helpful studies for developing intelligence because it prepares students for the changing state of life

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through mathematical thought patterns (Azkiah & Sundayana, 2022) . Thus, each individual must master mathematics well.

Understanding mathematics participants' education can be influenced by several factors to obtain optimal learning results. Various factors cover external and internal factors. External factors influence the understanding of mathematics, including learning methods, models, and strategies (Diana et al., 2020) . According to Nisa & Muhtar (2022), an appropriate learning model is needed to give students an understanding of the material.

Beyond the previously mentioned external elements, the student's internal factors also influence mathematical learning outcomes. According to the National Council of Teachers of Mathematics (2000), there are five mandatory learning process standards mastered by students, namely: 1) ability to solve the problem; 2) mathematical references and proof; 3) communication skills; 4) linking idea skill; and 5) representation skill. Mathematical representation ability is one of the skills a student must have to solve a math problem. When studying math, students are encouraged to focus on various forms of mathematical representation to address the mathematics problem properly (Afriyani et al., 2018) .

Mathematical representation is one of the components that deal particularly with the student's cognitive development in the learning process. Mathematical representation is a process of interpreting a problem by developing a student's mindset, which is a mathematical knowledge-building and abstraction process (Umbara et al., 2020) . Niss & Højgaard (2019) describe the ability of mathematical representation as the ability to interpret an object of mathematics or phenomena into symbols, verbal, graphic, diagrams, or visuals to correct a mathematical problem. Yudhanegara & Lestari (2015) point out three aspects of the present's mathematical ability: mathematical visual, symbolic, and verbal representation. The mathematical representation ability of a student is low. This matter was expressed by Fitrianna et al. (2018), who said that students have low mathematical representation ability because of difficulty presenting data according to the description provided.

Mathematical representation ability can be developed through context-based learning (Clarke & Roche, 2017) . Problem solving based contextual problems require exellent mathematical representation ability. Student's ability to solve contextual based math problems can thus encourage students them to discover a mathematical concept and idea independently and contribute to the student learning process (Priyadi & Yumiati, 2021) .

Students can develop their knowledge and skills by studying mathematics-based contexts. Contextual problems are those related to activities in daily life (Achir et al., 2017) . The contextual problems containing daily life activities require students to interpret problems into mathematical forms to be solved to obtain a solution. Contextual problem-solving needs to manipulate reading ability and interpret a problem for reference to mathematical concepts (Pradana & Murtiyasa, 2020). It is also supported by Anditiasari (2020) research that math requires problem-solving ability as well as mathematical storytelling, and good literacy ability is required.

Based on an interview with one of the mathematic's teacher at SMA N 1 Sukoharjo, previously never experienced the problem of mathematical representation capability on students but that math learning has already been linked to real-life contexts. Thus, researchers will research to identify the

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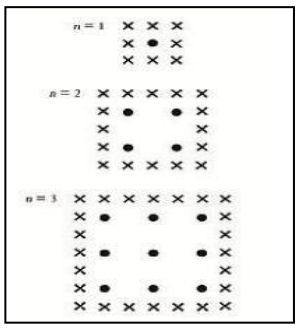
student's mathematical representation ability with a contextual problem based on mathematics.

2. Method

This research uses a qualitative research model with a descriptive method. Sutama et al. (2022) mention that qualitative studies are conducted to obtain in-depth and meaningful data. Research data retrieval was performed at SMA N 1 Sukoharjo with the subject of 34 students in class XE 10. Thirty-four subjects were given a mathematical representation test based on contextual problem solving to identify the type of mathematical representation capability about that visual, symbolic, and verbal representation capability. Furthermore, six subjects were selected according to their mathematics representation ability: two subjects capable of representing visual mathematics, two subjects capable of representing mathematical symbolism, and two subjects capable of representing verbal mathematics. To strengthen primary data by providing analytical descriptions to students in solving problems, interviews were conducted. The data obtained was analyzed using reduction and representation data, and drawing conclusions (Miles & Huberman, 1992).

Tests for obtaining primary data on student representation capabilities on contextual problems with material sequence and progression arithmetic and geometry. Math teachers and professors verify instrument resources before being tested to students. The instrument test used in research is displayed in the following Table 1:

Table 1. A Contextual Problem of Sequence and Progression Arithmetic and Geometry

No.	A Contextual Problem of Sequence and Progression Arithmetic and Geometry
1.	At the SMA N 1 Sukoharjo anniversary, the Student Council cheered him up. One of the Student Council races was a softball. The student council is stacking six cans. The top or first row has as many as 2 cans. The second row has 4 cans. The third row has 6 cans and so on with the same row pattern. Danang is in the race. In order for Danang to win the race, a strategy is needed. a. Write the completion plan if Danang wants to calculate the total number of cans that were dropped! b. If Danang can drop down all of the cans, then the total number of cans that were dropped was 56. Right or wrong? Give a reason!
2.	**My Beautiful Garden**  × is a stained-glass; ● is a plant flower Each student at SMA N I Sukoharjo will contribute to the school's backyard by planting flowers. They give the flower a stained-glass bottle around it to give it

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No.	A Contextual Problem of Sequence and Progression Arithmetic and Geometry
	an aesthetic appearance. The arrangement of the bottle and its flowering plant is like the picture of the pattern above. Flower planting and the tunneling continued like the above pattern until it found a specific n that caused the same number of flowering plants and glass bottles. a. Can you find the math process and tell me how many of them are n? b. Draw a diagram of the bar number of glass bottles and the number of flowering plants toward n!
3.	Ana is a religious novelist. In January, the novel sold 3 copies, in February it sold 6, in March it sold 12. As of August, the number of sales increased exponentially from previous sales. If the price of the novel was Rp78,000 and she sold it for Rp88,000, a. What is Ana's profit in sales for 8 months? b. Draw a line diagram of the profit Ana gets each month!

The test results are scored according to the rubric for assessing mathematical representation skills according to Cai et al. (1996) to determine the predicate of students' mathematical representation ability in solving mathematical contextual problems. In addition, the problem-solving process carried out by students based on aspects of their mathematical representation ability will be described based on mathematical representation indicators. Researchers combine and triangulate all existing data from test results of mathematical representation ability about contextual problems and interviews in the analysis process. In this research, test and interview instruments are based on the mathematical representation adaptive of the Rista et al. (2019) indicators as presented in the following Table 2:

Table 2. Aspects and Indicators Representation Mathematical

No.	Aspect Representation	Indicator
1.	Visual representation	Presents data, or information in a visual representation form (of charts, diagrams, and tables) to solve problems.
2.	Symbolic representation or expression	To solve issues using mathematical concepts and expressions to construct symbolic models or equations.
3.	Verbal representation	To solve the problem using words and write the steps to resolve it.

3. Results and Discussion

Based on the results of the representation ability test of mathematics based on contextual problems, the development of mathematics test shows that the student is ranked into the three aspects of representation, as in the following Table 3:

Table 3. Category Student According to Aspect Representation Mathematical

Aspect Representation Mathematical	Frequency	Percentage (%)
Mathematical visual representation	6	17.65%
Mathematical symbolic representation	10	29.41%
Mathematical verbal representation	18	52.94%
Total	34	100%

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Table 3 above shows, the distribution of representation abilities of mathematics based on some aspects. Most students' ability represents verbal mathematics, amounting to 52.94%. Whereas students who can picture mathematical symbols were 29.41%. Students who can represent visual mathematics have the smallest amount, only 17.65% of the total. Each student has a different problem-solving, so the representation ability also varies. The statement is backed by research by Huda et al. (2019), who found that every student has unique competencies to finish a problem.

3.1 Mathematical Visual Representation

The student who has mathematical visual representation capability tends to solve contextual problems by using diagrams such as the problem-solving in the students shown in the following Figure 1 and Figure 2.

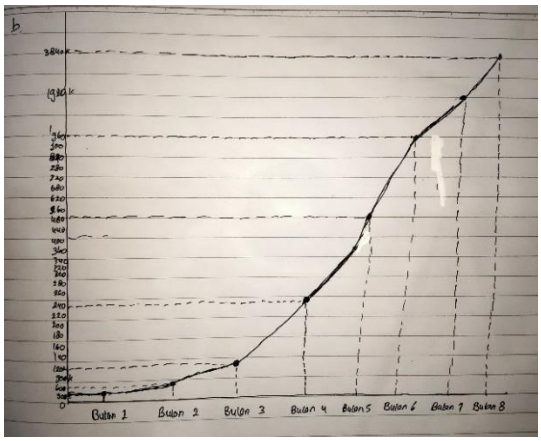

Figure 1. Problem-solving 1 by EAB student

Figure 1 and Figure 2 indicate that EAB students can interpret contextual problems into diagram pictures. The diagram drawn by the EAB student shows that consistent intervals of coordinates result in a corresponding line diagram and bar diagram. In addition to being able to place the correct X and Y coordinates. EAB students who prefer problem-solving rather than procedural, supported by analysis of interview results.

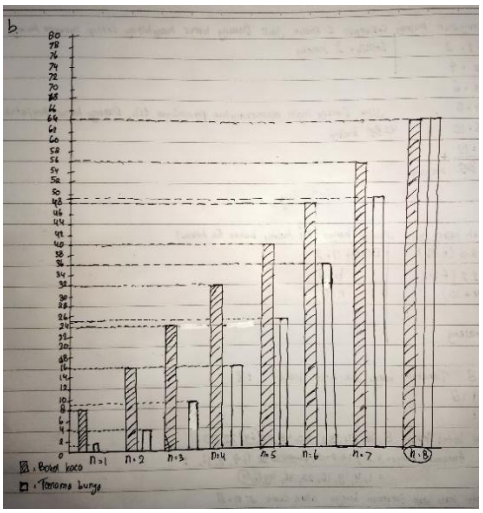

Figure 2. Problem-solving 2 by EAB student

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Here is a transcript of the interview with EAB students.

P : "Which issue do you think is the easiest one?"
EAB : " The question asked to draw the ma'am, questions 2b and 3b?"
P : "Why do you find it easy to solve the problem?"
EAB : " Because I feel it easier than counting by the formula."
P : "Do you understand this diagram that you drew?"
EAB : " I understand it, ma'am."
P : "Please, try to figure out the diagram you have made."
EAP : "The profit for the sale of novels in January was thirty thousand rupiahs, the profit for the sale of novels in February sixty thousand rupiahs, until August that kept rising in profits."

Students with the ability of a mathematically visual representation could solve visualization problems correctly. Images are produced in detail to produce an accurate diagram. Reinforced by the findings of Marifah et al. (2020), students with mathematical visual representation capabilities are more likely to be meticulous and more detailed in manufacturing charts and diagrams included in title writing and identification on the charts. Students with mathematical visual representation capabilities are more likely to solve visual problems.

4.1 Mathematical Symbolic Representation

Students with mathematical symbolic representation capability are more likely to solve the problem by using formulas, symbols, and mathematical expressions, such as problem-solving by students shown in the following picture 3:

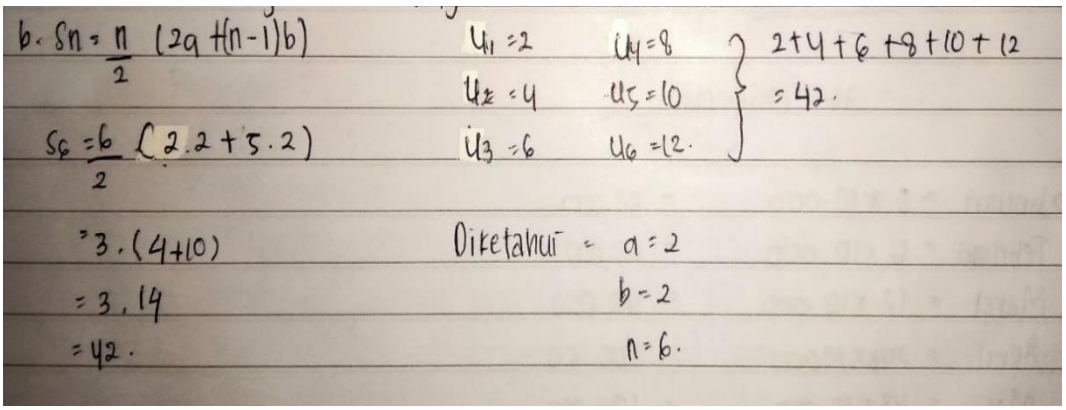

Figure 3. Problem-solving by HRM students

Figure 3, indicate that students with mathematical symbolic representation abilities are likelier to use mathematical symbols. By writing it using mathematical symbols, HRM students could demonstrate what is already known. Problem-solving also involves a systematic approach. These results were supported by interviews of HRM students with transcripts as follows:

P : "Would you prefer a matter that is calculated with a formula or a matter that is related to drawing like a drawing a diagram or chart?"
HRM : "Preferable direct calculation enters to formula, ma'am."
Q : " Why ?"

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HRM : "For when it comes to formula, only the number counts."
P : "Do you find it more difficult to solve question numbers 2b and 3b that were told to draw the diagram than the rest?"
HRM : "Yes, ma'am. I found it difficult to draw the diagram."

Students with symbolic representation ability solved the problem by writing mathematical symbols. In addition, the student solved the problem by using systematic steps, formulas, and calculations. This is supported by Komala & Afrida (2020) research that students with symbolic representation ability can solve the problem by presenting it in the form of a mathematical model of algebra or mathematical expression. Students prefer solutions using the available formulas rather than using mathematical concepts.

5.1 Mathematical Verbal Representation

Students with mathematical verbal representation abilities are more likely to solve the problem with phrased sentences, such as the result of the SKF student problem described in Figure 4 as follows.

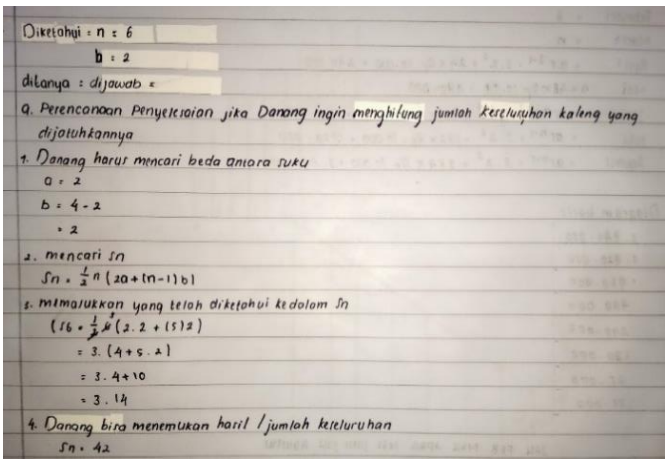
Diketahui : n = 6
b = 2
ditanya : dijawab =
a. Perencanaan Penyelesaian jika Danang ingin menghitung jumlah keseluruhan kaleng yang dijatuhkannya
1. Danang harus mencari beda antara suku
a = 2
b = 4 - 2
= 2
2. mencari Sn
$Sn = \frac{1}{2} n [2a + (n-1)b]$
3. memasukkan yang telah diketahui kedalam Sn
$(S6 = \frac{1}{2} 6 (2.2 + (5)2)$
$= 3.(4+5.2)$
$= 3.4+10$
$= 3.14$
4. Danang bisa menemukan hasil / jumlah keseluruhan
Sn = 42

Figure 4. Problem-solving by SKF students

Based on Figure 4 above, students with mathematical verbal representation abilities tend to solve mathematical problems using new words followed by mathematical symbols. This is like when the teacher gives an oral explanation to the student about the steps of problem-solving. According to Huda et al. (2019) research, students with the ability to mathematical representation can generally resolve problems using mathematical problem-solving measures using words and writing an interpretation of a representation. The analysis of the problem is supported by an interview with SKF students with transcripts as follows:

P : "Would you prefer a problem where you finish using a description sentence, mathematical formula, or drawing?"
SKF : "Prefer the one with the word ma'am."
P : " Why so? "
SKF : "Because if counting, I am confused about calculating it, and if I looked at the picture, I did not know what it looked like, ma'am. If with the sentences, I feel easy to remember it."

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Students with mathematical verbal representation abilities tend to solve mathematical problems using sentences or words. Students write phrases such as new oral explanations followed by mathematical symbols if available because explanations in sentences are more accessible for students to remember than symbolism and other visuals. According to Wati et al. (2019), who found that students who tend to be able to absorb learning conducted by teachers through verbal teaching can write mathematical sentences correctly. In addition, research by Wati et al. (2019) also mentioned that verbal representation ability does not have work steps but only directly writes the answer to the problem.

4. Conclusions

Based on the results of this research, the mathematical representation abilities of students based on contextual problems are different. Students with mathematical visual representation abilities are more likely to be able to solve visual problems, such as drawing diagrams with accurate results. Students with mathematical symbol representation abilities are more likely to solve mathematical problems using mathematical symbols and a systematic approach to completion. Students with mathematical verbal representation capabilities are more likely to solve the problem using words or words like verbal explanations.

In the conclusions and recommendations of the conducted research, it is suggested that future investigations broaden the scope of the assessment instrument to include arithmetic and geometric sequences and progression material. This would enhance the precision and specificity of the predicate about mathematical representation ability. Future researchers can also conduct research with mathematical problems with other materials in order to assess the degree of proficiency in mathematical representation and discuss strategies for improving the mathematical representation skills of students deemed to be deficient.

Author Contributions

The first authors contributed to formulating research, designing research methods and instrumentation. In addition, the first writer also acted as an observer, analyzing data produced by research, documenting, and textual writing. The second author acted as an advisor both in the text and in the process of extracting data from research.

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Declaration of Competing Interest

According to the author, there was no conflict of interest in this research.

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