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MATHEMATICAL REPRESENTATION ABILITY OF STUDENTS WITH MODERATE VISUAL SPATIAL INTELLIGENCE IN SOLVING SOLID FIGURE PROBLEMS

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ABSTRACT

The importance of the ability of representation as a standard process of learning mathematics because it can help students understand and develop every concept in learning mathematics. The representation of each element of intelligence which dominates a lot is visual-spatial intelligence because it is an object that can be seen visually. However, it is known from previous researchers that the ability of students' mathematical representations is still relatively low. This is due to the habit of students receiving direct learning and passive activities. This research is a qualitative research that aims to describe the representation abilities of students with visual-spatial intelligence who are currently solving geometric problems. The subjects of this study were class XII MIPA students at SMAN 9 Enrekang. Data were collected using a visual-spatial intelligence test instrument, a mathematical representation ability test instrument and interviews on students' mathematical representation abilities. The data that has been obtained is analyzed using the Nvivo 12 Plus application. The results showed that students with visual-spatial intelligence were able to represent problems visually and verbally in solving spatial geometry problems but could not represent them mathematically. This is based on the fact that students are not precise in choosing the mathematical model used in solving geometrical problems so that students experience problems in solving the next problem. Choosing innovative learning methods and getting students used to working on questions that require higher-order thinking skills can support students' mathematical representation abilities.

Keywords: Mathematical Representation, Spatial Visual Intelligence, Solid Figure

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PRELIMINARY

To determine the level of students' understanding in solving a problem, a mathematical representation can be used (Hudiono, 2010). Cahdriyana et al (2014) explains that the idea of representation is one that arises from the search for solutions to mathematical problems. These ideas are used as a tool to increase their capacity in mathematical conversation. Utilizing representation as a mathematical reasoning tool will make it easier for users to manage problems. The document was published by Sabirin (2014), which states that representational skills are very important for women to have because they are related to forms of visual communication, such as graphs, diagrams, and other forms that are easy to understand. can be used for troubleshooting.

Teachers use representation as a standard method of teaching mathematics because it can help students understand and develop each concept in a subject and is used to communicate students' ideas or thoughts in written form which will later be used as a tool for teachers to assess how well students understand new concepts. just taught. This is in line with what Mudzakir (in AR & Mahmud, 2018) wrote about the benefits that students can get from using mathematical representation skills, such as forming various situations that can be used for teaching, increasing the ability to understand a particular problem, and increasing the ability of mathematical representation, which can be used as a tool to solve problems. Early educational psychology placed a strong emphasis on individual characteristics. People can be classified as visual learners (also known as visualisers) or verbal learners (also known as verbalisers) according to the Dual Coding Theory (Paivio, 1986). However, Massa & Mayer (2006) found little empirical support for the idea that giving visual learners visual teaching and giving verbal instruction to verbal learners would improve performance. Instead, they discovered that including visual aids in a predominantly text-based online session tended to benefit both verbalizers and visualisers. A previous study on learning a second language by Plass et al (1998) found that text and visuals together produced superior learning outcomes than text alone. Research results from this theoretical perspective increase the likelihood that our prediction will come true.

Indicators on the ability of mathematical representation can be seen in the following table.

Table 1. Indicators of Mathematical Representational Ability

Ability Type Representation	Indicator
Representation Visual	Illustrate geometric problems into shapes . Provides solutions to problems with involve picture.
Representation Symbol	Understand something symbol from modelmath .

Ability Type Representation	Indicator
	Create a mathematical model.
	Solving problems using a mathematical model.
Representation verbal	Make the problem situation verbal.
	Summarize answers.

Spatial visual intelligence is the single most important factor that interferes with students' ability to represent mathematics (Asyrofi & Junaedi, 2016). Each component of intelligence is represented differently when compared to the context in which it occurs because objects are visually visible objects (Masturi et al., 2021). Diezmann & Watters (2000) give opinion that intelligence visual spatial can be deduced from the ability to summon and use certain representations and reasoning. Lower scores (Berends, I. E. van Lieshout, & Ernest, 2019; Kaminski, J. A., Sloutsky, V. M., & Heckler, 2008) or no effect Dewolf et al (2014) have been observed in research on the use of more depictive representations in (word) problem solving . In contrast to this study's findings, which were based on spatial visual capacity but are still addressing geometric issues.

Indicators of spatial visual intelligence can be seen in the following table.

Table 2. Indicators of Spatial Visual Intelligence

Spatial Ability	Indicator
Spatial Relations	Identify a series of objects and their parts.
	Defines the relationship between objects.
Visualization	Identify different.
	Define different.
Logical consistency	Identify linkages between patterns.
	Determine the relationship between patterns
Perceptual Spatial	Identify the confounded direction.
	Defines the confounded direction.

Suningsih (2021) explains that the achievement of mathematical representation abilities means that students tend to use visual representations and expressions in solving problems. This shows that students' mathematical representation abilities still need attention to be improved. The importance of the ability of representation as a standard process of learning mathematics because it can help students understand and develop every concept in learning mathematics. The representation of each element of intelligence which dominates a lot is visual-spatial intelligence because it is an object that can be seen visually. However, it is known from research conducted by Diasa (2021) that students' mathematical representation skills are still relatively low. This is due to the habit of students receiving direct learning and passive activities. This research update examines the mathematical representation abilities of students who are analyzed using the Nvivo 12 Plus application with a higher level of data accuracy than before.

Based on description the so researcher interested For conducted research on "Mathematical Representational Ability of Students with Moderate Visual Spatial Intelligence in Solving Solid Figure Problems".

METHODS

This type of research is research qualitative Bogdan & Taylor (Moleong, 2012) concluded that descriptive words are the results obtained by researchers in the data collection process where the main subject in qualitative research is the researcher himself. The implementation of this research was carried out in the 2022/2023 school year with located at SMA Negeri 9 Enrekang. The population in this study were students of SMAN 9 Enrekang. Due to the limitations possessed by the researcher, the research subject was chosen, namely class XII MIPA students of SMAN 9 Enrekang who had studied spatial geometry material.

Data was collected using a multiple choice test instrument totaling 20 questions which had been validated by expert validators in the field of mathematics and mathematics teachers at SMAN 9 Enrekang to measure students' visual-spatial intelligence. The subjects in this test were 55 students. The results of the spatial visual intelligence test are categorized using the standard deviation formula as shown in the following table.

Table 3. Determination of Spatial Visual Intelligence Categories

No	Intervals	Category intelligence spatial
1	$X > \bar{X} + SD$	Height
2	$\bar{X} - SD < X \leq \bar{X} + SD$	Moderate

No	Intervals	Category intelligence spatial
3	$X \square \bar{X} - SD$	Low

Information :

SD : Standard Deviation

$\bar{X}$: Average X

X : Mark

(Arikunto, 2013).

The data in each of these categories is presented in the following table.

Table 4. Visual Spatial Intelligence Test Results

No.	Category	Scor	The number of students
1	Height	X > 58,08	9
2	Moderate	35,91<X≤ 58,08	34
3	Low	X ≤ 35,9149	12

Based on the calculation of the results of the visual-spatial intelligence test on 55 students, then representatives of students with moderate visual-spatial intelligence were selected to solve geometric shapes in the form of descriptions. The following is the instrument for the given spatial problems.

" A bathtub has a volume of 315 liters with a length of 90 cm and a height of 70 cm. Above the tub, a water faucet with a height of 10 cm will be installed right in the middle between points H and G of the bathtub provided that the AB line is at the front and bottom, then on one side of the bathtub a drain will be installed in the middle between the point A and point B as in the following figure.

a. Determine the distance between the faucet and the drain from the tub if they are opposite each other."

This question has been validated and declared fit to be used as a research instrument because the question is a HOTS (Higher Order Thinking Skill) question which is a type of question designed to measure students' ability to think at a higher level or students' ability to think critically, analytically, synthesise, evaluatively, and also creative needed in students' mathematical representation ability. The results of the students' answers were then confirmed using the interview method. The results of data collection were then analyzed using the Nvivo 12 Plus application.

RESULT AND DISCUSSION

In the following, excerpts from interviews between researchers and research subjects will be presented bellow.

P : Tell me what you understand from the problem.

SS : The volume of the bath is 315 liters with a bath length of 90 cm and a height of 70 cm. then above the bathtub installed a water faucet with a height of 10 cm between the tubs. A drain is installed between A and B.

P : What symbols do you use to solve the problem?

SS : Symbol “A,B,C,D,E,F,G,H” for bathtub and PQR. Not only that I use the symbol v, p and t

P : What does each symbol you make mean?

SS : PR is the slanted side, v is the volume, p is the length and t is the height.

P : Tell me the math model you made?

SS : Using the Pythagorean theorem and to find the width, I used the formula for length times width times height.

P : Why is the result from liters to cm 31.500?

SS : Because I don't know and just guessing.

P : How do you solve the problem using ?

SS : By using an image of a tub in the form of a beam, namely the ABCDEFGH beam and a PQR triangle image for what is asked.

P : What conclusion do you get from this problem?

SS : So, the length or distance between the faucet and the drain is $\sqrt{6425}$ cm .

Information provided by researchers:

P: Researches

SS: Subject

a) Visual Representative

The results of working on the subject can be seen in the following figure.

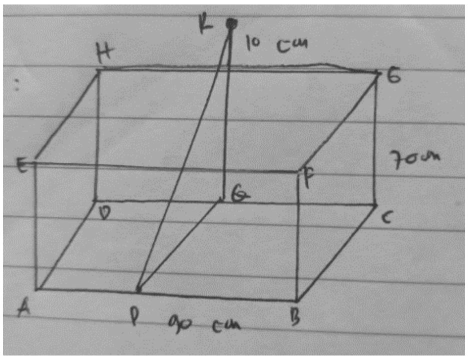


Figure 1. Capability Representation Visual Subject SS

The following figure shows the results of excerpts from interviews between SS subjects and researchers who related with test ability visual representation which has been analyzed using *Nvivo 12 Plus.*

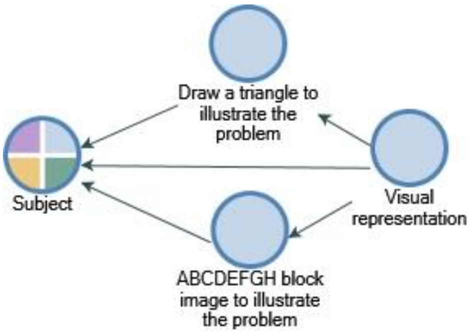


Figure 2. The Results of The Analysis of The Visual Representation

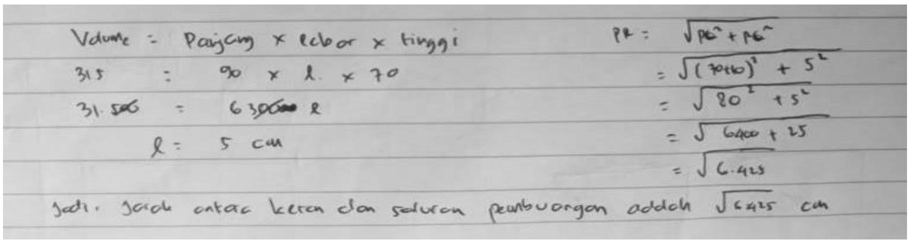
Comparison of the answer sheets and the results of interviews with SS subjects based on the results of the analysis in Figure 2, it can be seen that SS subjects are able to present problems by involving pictures. When asked "how do you solve the problem by using?" using an image of a tub in the form of a beam, namely the ABCDEFGH beam and a PQR triangle image for what is asked. Triangulation of visual representation abilities of SS subjects is presented in the following table..

Table 5. Triangulation of SS Visual Representation Ability in Question 1

Indicator	Test Results	Interview	Information
Presenting geometry problems into shapes	√	√	Consistent
Solve the problem with involve picture	√	√	Consistent

b) Representative Mathematical Expressions

The results of student work can be seen in the following figure.



English Version

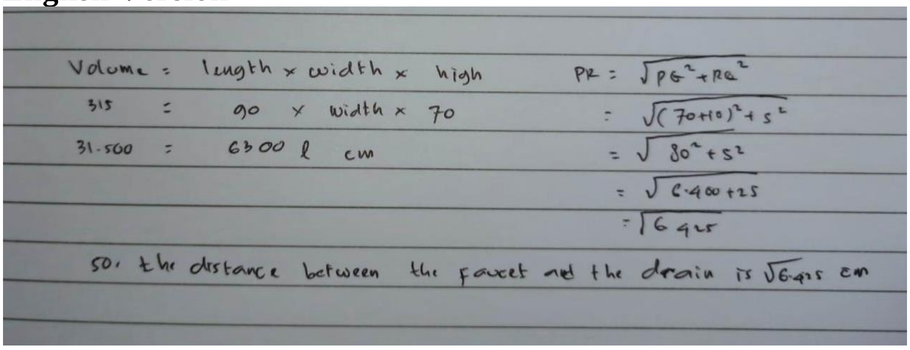


Figure 3. Capability Representation Mathematical Expression Subject

The following figure shows the results of excerpts from interviews between subjects and researchers related to tests of ability to represent mathematical expressions that have been analyzed using Nvivo 12 Plus.

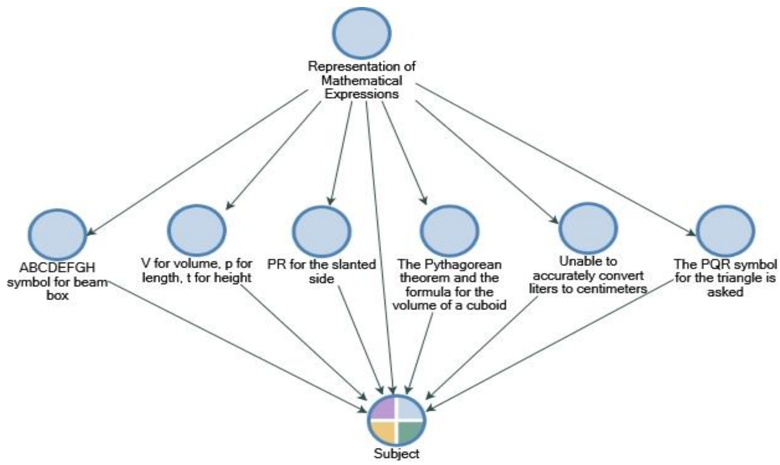


Figure 4. The results of the analysis of the mathematical expression representation

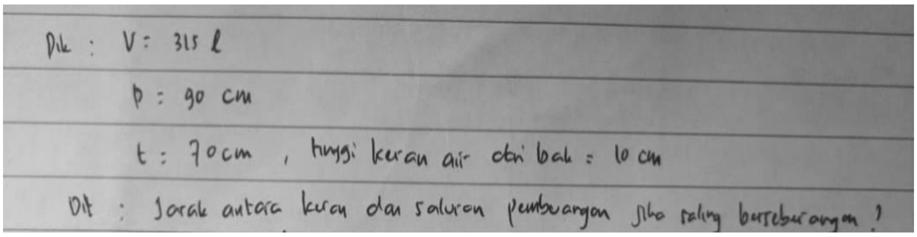
Based on the results of the analysis in Figure 4, it can be seen that the subject is able to use symbols to solve problems, namely symbols *A, B, C, D, E, F, G, H* for the bathtub and *pqr* for the illustration in question. In addition, the subject uses the symbols *V, p, l* and *t* where for V is volume, *p* is length, *l* is width and *t* is height and for *p,r* the slanted side. So that in solving this problem the subject uses a mathematical model with the volume formula of the beam first to find the width of the bathtub and the Pythagorean formula to find the distance between the faucet and the drain. Based on the description of the answers given it can be concluded that the SS Subject meets the indicators understand a symbol of a mathematical model, create a model mathematics but unable finish problem with use model math properly. Triangulation ability representation symbol subject SS served on following table.

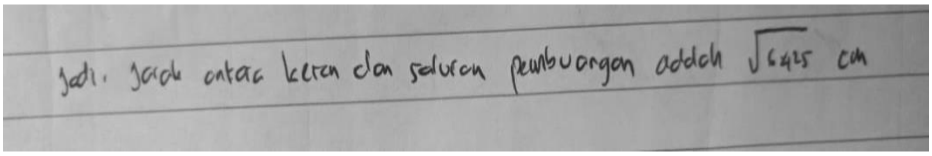
Table 6. Triangulation of Mathematical Expression Ability

Indicator	Test Results	Interview	Information
Understand something symbol of models mathematics	√	√	Consistent
Create models mathematics	√	√	Consistent
Solving problems with use mathematical models	X	X	Consistent

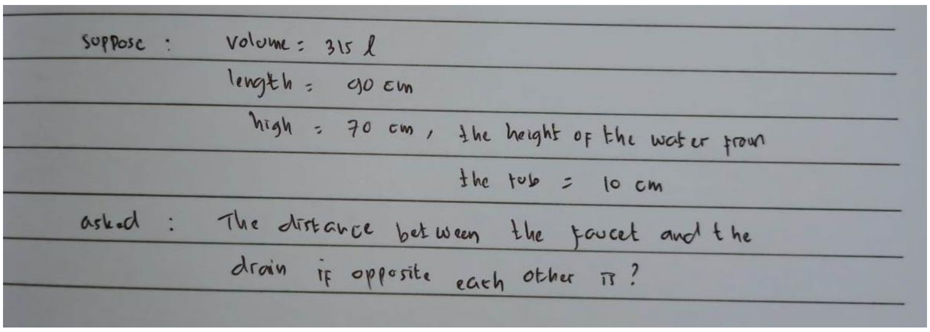
c) Verbal Representative

The results of student work can be seen in the following figure.





English Version:



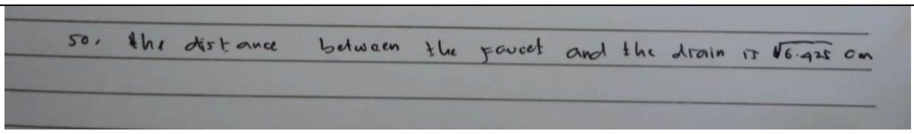


Figure 5. Capability Representation Mathematical Expression Subject

The following figure shows the results of interview excerpts between subjects and researchers related to verbal representation ability tests that have been analyzed using Nvivo 12 Plus.

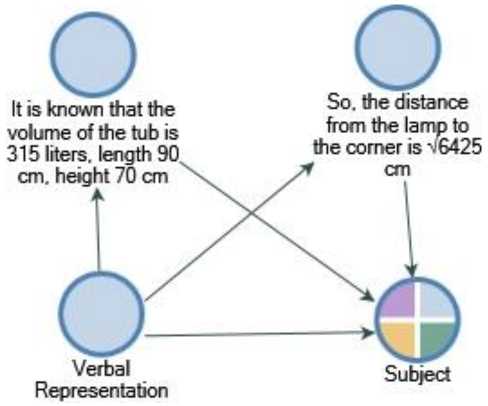


Figure 6. Results of the analysis verbal representations

Comparison sheet answer question And results interview on the subject based on the results of the analysis in Figure 6 it can be seen that subject was able to write down what was known, namely the volume was 315 liters, the length was 90 cm, the height of the water tank was 70 cm, the height of the faucet leading to the water was 10 cm. For those who are asked about the distance between the faucet and the drain. The SS subject also wrote a conclusion in end the answer is the length or distance between the faucet and the drain is $\sqrt{6425}$ cm but the answer is not correct. Triangulation SS subjects' verbal representation abilities are presented in the following table.

Table 7. Verbal Representative Ability Triangulation

Indicator	Test Results	Interview	Information
Make situation problem in verbal form	√	√	Consistent
Summing up resultssolving problem	X	X	Consistent

Student with category intelligence visual spatial currently can illustrate the problem given in the geometric problem in the form of an image. Not only that, students with moderate visual-spatial intelligence can verbally illustrate spatial problems and draw a conclusion from what is obtained, even though the final conclusion is not quite right. This is because students with visual-spatial intelligence are not quite right in solving problems in mathematical expressions because they are not appropriate in using mathematical models.

A student who has moderate visual-spatial intelligence can connect some of what they know with visual geometry and represent it through words but is not precise in the description (Riastuti et al., 2017). Intermediate level subjects experience some difficulties associated with scratches on paper which are used as a tool to visualize changes in the shape of objects (Kurniawan, 2018). Students with moderate spatial intelligence have good mathematical representation skills (Henradi, 2021).

CONCLUSION

Based on the findings of the research results, the researcher draws a conclusion that students with visual-spatial intelligence are being able to present and solve problems by involving pictures appropriately in solving geometric shapes. These results are based on students' ability to represent spatial geometry problems visually correctly. Students with moderate visual-spatial intelligence in solving geometrical problems can understand the mathematical symbols that have been made but cannot use mathematical models to solve spatial geometry problems correctly. Students with moderate visual-spatial intelligence in solving geometric problems cannot draw conclusions from solving the problem precisely because the completion of the mathematical model used is still not quite right.

Based on the results of the study, the researcher gave several suggestions, namely that the research subjects were limited to class XII MIPA students of SMAN 9 Enrekang who had visual-spatial intelligence. Assessing the ability of mathematical representation is not only limited to students, but also students or other intellectuals. Mathematical representation ability is not only based on visual-spatial intelligence but also on linguistic intelligence, logical intelligence, kinaesthetic intelligence and so on. Not only that, the problems given in this study are limited to spatial geometry problems which are designed in the form of descriptive questions. To find out the ability of mathematical representation is not only limited to spatial geometry material, but can also cover other material such as algebra, calculus, trigonometry and other mathematical sciences.

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