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Editors

M Haviz
IAIN Batusangkar
Biology Education
Jalan Sudirman Nomor 137 Kubu Rajo Limo Kaum
Batusangkar, 27213
Indonesia

Email: mhaviz@iainbatusangkar.ac.id

Ika Metiza Maris
IAIN Batusangkar
Mathematics Education
Jalan Sudirman Nomor 137 Kubu Rajo Limo Kaum
Batusangkar, 27213
Indonesia

Email: ikametizamaris@iainbatusangkar.ac.id

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Table of Contents

COMPUTER SCIENCE AND TECHNOLOGY

Preface: International Conference on Education Science and Engineering (ICoESE) 2021

We are delighted to present the proceeding of the International Conference on Education, Science and Engineering (ICOeSE). ICOeSE has held on September 29-30th, 2021 virtually in Batusangkar, West Sumatra, Indonesia with theme "Science, Technology, and Engineering in Educational Transformation in Society 5.0". This conference aims to provide to invite all parties who are concerned with global issues about improving the quality of the education system in facing the era of society 5.0 and to open international forums. So, that participants have the opportunity to convey ideas, experiences, expertise, and knowledge about global issues about education, science and technology and engineering as an effort to develop the quality of education. This theme has discussed in in spesific topics biology, physics, mathematics, chemistry and computer science and technology.

Finally, we like to express our gratitude to the Rector of IAIN Batusangkar, Dean of FTIK and all committee colleagues who have made efforts to organize this activity.

Thank You
Batusangkar, October 30th, 2021
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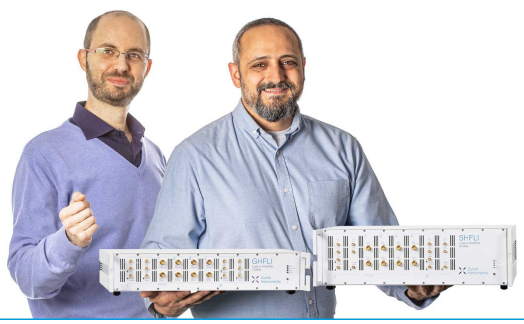

Mathematical Representation Ability Viewed by Mind Styles on Solid Geometry

Risnawati[1,a)], Nasir Za'ba[1,b)], Hayatun Nufus[1, c)], and Ririn Eviyanti[1, d)]

[1]*State Islamic University of Sultan Syarif Kasim Riau, Indonesia*

[a)] *Corresponding author: risnawati@uin-suska.ac.id*
[b)]*nasirzaba@gmail.com*
[c)]*hayatun.nufus@uin-suska.ac.id*
[d)]*ririn.eviyanti@students.uin-suska.ac.id*

Abstract. Mathematical representation ability is one of mathematical competencies that should be mastered by students. One of the factors influencing student mathematic representation ability is students' characteristics of mind styles. This research aimed to analyze students' mathematic representation ability viewed from mind styles on the solid geometry topic. The subjects of this research were 95 students that were reduced to 12 students of State Islamic Junior High School at Kepulauan Meranti Regency. It was qualitative descriptive research, and the instruments of collecting the data were in the forms of a test of mathematic representation ability, a questionnaire of students' characteristics of mind styles, and an interview of both the test and the questionnaire. All data were analyzed through reducing, presenting, and concluding and verifying data. The research findings showed that firstly, the CS students dominantly mastered both the visual and symbolic representation instead of the verbal one; secondly, the AS students were better in both the visual and verbal representation than in the symbolic one; thirdly, the CR students highly understood both the visual and verbal representation besides the symbolic one; and fourthly, the AR students generally mastered the visual and symbolic representation instead of the verbal one. This research recommends for teachers considering the right methods and strategies in upgrading the students' mathematical representation ability depending on their own students' mind styles.

INTRODUCTION

The mathematical representation ability is one of the important aims of mathematics teaching in schools. The mathematical representation ability as compiled by the National Council of Teachers and Mathematics (NCTM) means translating a problem in the forms of pictures, words, or symbols [1]. This obviously can be seen in the standard of mathematics learning applied by NCTM, those are to solve problems, to reason and prove, to communicate, and to connect and represent.

Here, the representation ability is divided into three indicators [2]. Those are verbal, visual, and symbolic representations. Verbal representation is the ability to express the words in written text. Visual representation is the ability to draw diagrams, graphs, and other figures. Symbolic representation is the ability to use numbers, equations, operations, and other symbols.

From the research studied by Rezeki [3], the students' mathematical representation ability effected their learning outcome. The better the students' mathematical representation ability, the higher the learning outcome, and vice versa. This means that the mathematical representation ability is important to be mastered.

However, the studies from the Program for International Student Assessment (PISA) said that representation is an evaluation aspect for mathematics literacy, but Indonesian students were in the 73rd ranking of 79 countries [4]. This research implied that Indonesian students were needed to improve their mathematics abilities, such as the representation ability. This condition also is in agreement with Fitriana research [5]. It told that the mathematical representation ability of senior high school students was still in a low predicate. Most of the students had difficulties in drawing the mathematics graph and in creating mathematical models or equations from the given problems.

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Our empirical studies from the interview with a mathematics teacher of Islamic State Junior High School at Kepulauan Meranti Regency suggested that students' learning outcome on the topic of the solid geometry was in the low predicate. Generally, the students of their school had difficulties to visualize the equation to the form of the model geometry and to write the steps of solving properly. This condition caused the exam rates of students on the solid geometry topic to decrease or not to reach the minimum score criteria.

One factor impacting the representation ability is the mind styles of students [6]. As Gregorc [7-8] said that the mind styles could be classified into four quadrants, those are concrete sequential (CS), abstract sequential (AS), concrete random (CR), and abstract random (AR). The students of each mind style had different ways to act and to convey an idea or a problem.

The results from other reserach that mind styles impacted the students' learning outcomes that applied the learning model of Two Stay Two Stray (TSTS) and Think Pair Share (TPS). Students with the CS and AR mind styles had better learning outcomes than those with the AS and CR mind styles. Students tended to use their mind styles for solving the test related to the equation and inequality topic. From the previous researches of representation ability and mind style, there were not available to discuss the topic of solid geometry. Because of that, this research focused on the solid geometry like cube, prism, and pyramid. The topic is taught for the eighth graders. Based on the given background, the researchers were interested to answer a question about "how are students' mathematical representation ability viewed by four mind styles on the solid geometry topic?".

METHOD

This research used a qualitative method and descriptive design. This method is based on the post-positivism philosophy that studies a problem in natural conditions in which the researcher is a key instrument. Subjects were 95 students then those were reduced to 12 students with purposive sampling with the consideration of students' mind styles. The students were eighth-graders of the islamic state junior high school number 2 at Kepulauan Meranti. Each student was given a questionnaire to determining their mind styles adapted from DePorter [8] and a test consisting of 9 items to evaluate their mathematical representation ability (see in **Table I**), and an interview related to their mind styles and mathematical representation ability.

TABLE I. The test items of mathematical representation ability

No.	Questions
1.	Explain what happens to a cube volume if its side becomes twice in size as the original one? Construct your model to detail your answer.
2.	If it is given that a base area and a height of a cube and both of a rectangular prism are the same in length, then, are the volume of the cube and that of the rectangular prism the same in size? Explain your answer with reasons, examples, and also constructions?
3.	A rectangular prism has a volume of 60.000 cm^3 and a width of 50 cm. Create a possible length and height of the rectangular prism, and construct your model to detail your answer.
4.	A right square pyramid has a side of base 6 cm and a height of 12 cm. Determine the volume of the pyramid and how is about the pyramid if its height becomes half in size of the original one?
5.	Ali has a toy box in the shape of a right square pyramid with a base side of 10 cm and a height of 12 cm. If Ali covers the box with a cover paper that has a price of 50 IDR/cm^2, then how many IDR will Ali pay?
6.	Ahmad has an aquarium in the shape of a right pentagonal prism with a base area of 30 cm^2. If Ahmad fills a three-quarter of the aquarium with water and the height of the aquarium is 40 cm, then how much water will Ahmad needs?
7.	Aisyah will give a gift to her sister. The gift is inside a box in the shape of a cube with a side of 20 cm. Aisyah buys a cover paper to wrap the outside of the box to be an interesting gift. At the shop, the cover paper is available with an area of 500 cm^2/sheet. Determine how many sheets Aisyah needs to wrap all surfaces of the box. Explain your steps with your sentences.
8.	If prism I and prism II have the same base area, and the height of prism I is half of the prism II, then how is the volume ratio of both prisms? Explain your reasons with your own sentences.
9.	A rectangular prism A has a ratio of length, width, and height 3:2:1 respectively and a rectangular prism B has twice the ratio of prism A. Is the volume of prism B twice the volume of prism A? Give your reasons and construct your model to detail your answer.

Data were analyzed with three steps: reducing data, presenting data, and concluding and verifying data. Data also were evaluated by four tests. Firstly, the credibility is to test the trustworthiness level by comparing the representation test and the interview, then comparing the test score and the rate ability criteria [9] with **Table II**. Secondly, the transferability is to know to what extent the research results can be applied in other situations. Thirdly, the dependability is to check the reliability by auditing all data. Fourthly, the confirmability is to compare and contrast the results with other research results.

TABLE II. Rate ability criteria

Interval	Predicate
85% < score ≤100%	Very good
75% < score ≤85%	Good
60% < score ≤75%	Sufficient
55% < score ≤60%	Bad
score ≤55%	Very bad

RESULTS AND DISCUSSION

After 95 eight-grader-students of the junior high school were given the questionnaire and the test, they were reduced to 12 students based on four mind style categories: concrete sequential (AS), concrete sequential (CS), concrete random (AR), abstract random (CR). Each group had three representative students and labeled S1, S2, and S3 for CS; S4, S5, and S6 for AS; S7, S8, and S9 for CR; and S10, S11, and S12 for AR. Results were divided into 12 categories based on three representation indicators (visual, verbal, and symbolic) and four mind styles (CS, AS, CR, and AR). The 12 categories were discussed as follows.

Concrete Sequential (CS) Students

The results of three subjects S1, S2, and S3 of the CS category could be seen in **Table III**. It told that the representation ability of CS students is on sufficient predicate for visual and symbolic representation, and is on bad predicate for verbal representation.

TABLE III. Results of CS students

Indicator	Overall score	Predicate
Visual	66.6%	Sufficient
Verbal	55.5%	Bad
Symbolic	62.9%	Sufficient

The CS students in visual representation ability answered the test sufficiently. Here is the answer of S1 on test number 1 shown in **Figure 1**. S1 could construct the cube correctly. S1 tried to indicate that the side of the right cube is twice in length as that of the left one. S1 assumed that the side of the left cube is 3 cm and the side of the right is 6 cm. This assumption was very good and representative to solve the test item number 1.

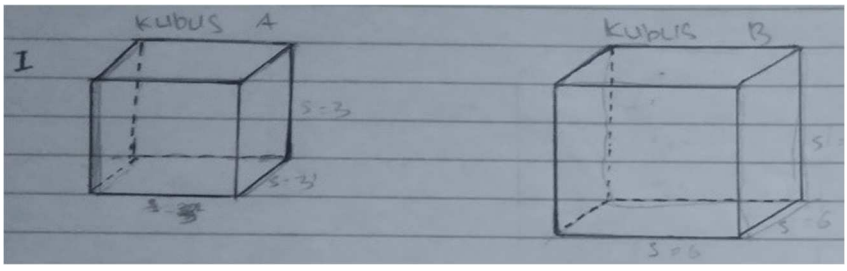
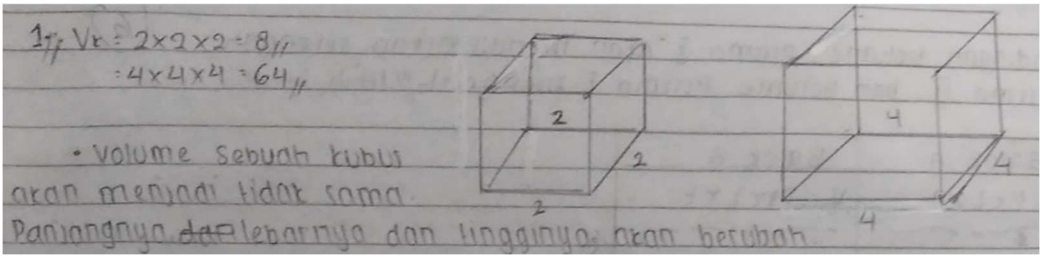


FIGURE 1. The answer of S1 on test item number 1

However, in visualizing, S1 did not correct in constructing the cubes. At a glance, the side of the right cube is not twice in length than that of the left one, but this lack is covered with the explanation of the length of both cubes. S1 reasoned from the interview that S1 gave the explanation of the length of both cubes so that it could cover the lack of construction visualization.

For the verbal representation ability of CS students, overall students answered the questions badly. Here is the S2 answer as seen in **Figure 2**. Item number 1 asked what happens to a cube volume if its side becomes twice in size of the original one. From the interview, S2 said that the volume of a cube will differ and even either its length, width, or height will change.



Translation:
"*Volume of a cube will differ. Either its length or width or height is modified."*

FIGURE 2. The answer of S2 on test item number 1

Nevertheless, S2 could not explain verbally how the volume differs with the change of the side length. S2 could not explain the proportional relation of the size changes. S2 was still confused with this explanation so that S2 thought that the left cube volume was also twice in size as the right cube volume, which it should be eight times in size.

The result of CS students, S2, for symbolic representation is presented in **Figure 3**. The overall score for CS students solved the problems sufficiently as S2 did. Item number S2 could maximize S2's symbolic ability but S2 could not solve the problem number 3 until getting the length and the height of the given rectangular prism. S2 only could analyze the variable until "*p* multiplied by *t* equals 1200".

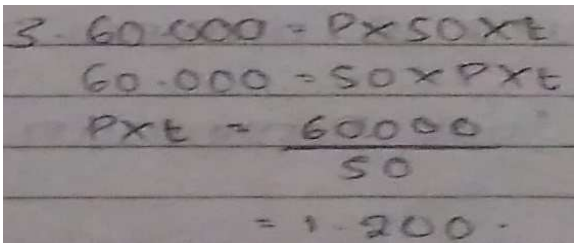


FIGURE 3. The answer of S2 on test item number 3

From the interview with S2, S2 said that S2 did not use the symbol volume in the early answer so that the answer systematics and the formula derivation were not presented completely. After all, S2 still could represent the symbols more properly, if S2 was trained more often to analyze this kind of problem.

Abstract Sequential (AS) Students

Other results of subjects S4, S5, and S6 of AS category were explained in **Table IV**. Data said that the representation ability of AS students is on very bad predicate for visual and verbal representation, and is on sufficient predicate for symbolic representation.

TABLE IV. Results of AS students

Indicator	Overall score	Predicate
Visual	52.7%	Very bad
Verbal	53.0%	Very bad
Symbolic	61.6%	Sufficient

The AS students solved the problems very badly for visual representation ability. **Figure 4** visualizes the work of S5 as one of the AS students. S5 could construct the models very well for both cubes asked in item number 1. S5 also added the length of the side of both cubes that were double size in comparison, but S5 failed to solve the problem.

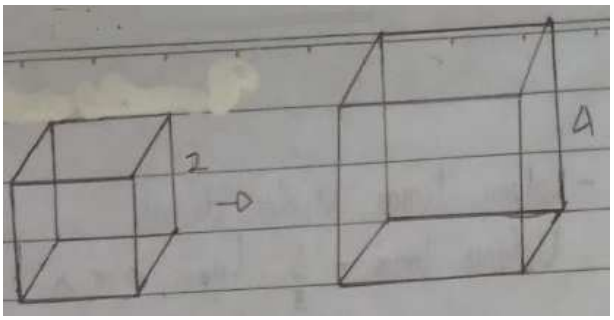
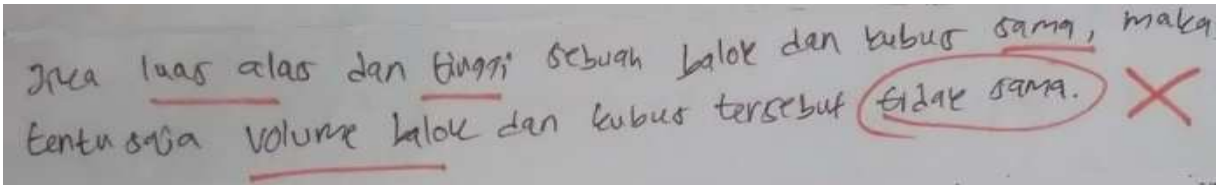


FIGURE 4. The answer of S5 on test item number 1

S5 explained in the interview that S5 did not know how to explain what happened to the right cube after a change was applied. S5 only represented the model construction of both cubes.

For the verbal representation ability, AS students solve the test also very badly. The solution that S6 wrote in **Figure 5** showed S6's wrong explanation. S6 wrote the explanation clearly with the good words, but S6 failed to answer the item number 2 correctly.



Translation:
"If a rectangular prism and a cube have the same size in the base area and the height, then certainly the rectangular prism and the cube did not have the same size in the volume."

FIGURE 5. The answer of S6 on test item number 2

In S6's interview, S6 told why the answer become like that. S6 said that the volume of the rectangular prism and the cube was different in size because originally both solid geometry shapes had a different base shape. The rectangular prism had a base of a rectangle shape, whereas the cube had a base of a square shape so that both volumes could not be the same in size.

The results of the AS students were evaluated as a sufficient predicate. S4 as one of the AS students answered the problem of item number 3 correctly. In **Figure 6**, S4 understood and used the symbols properly so that S4 could get the solution for the question. S5 could analyze the variable of the question and could interpret the aim of the question very well, but S4 could conclude the answer into the final statement of what the values of the length and the height were.

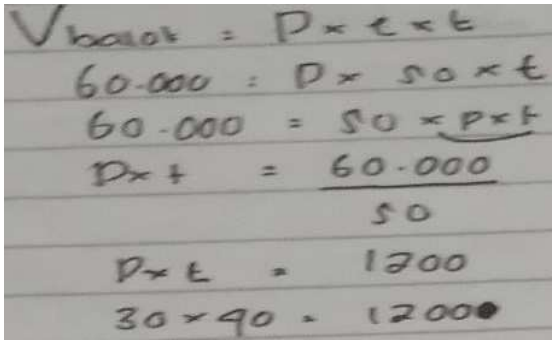


FIGURE 6. The answer of S4 on test item number 3

In the interview, S4 could give the meaning of each symbol that S4 made. S4 could choose the right formula to solve the problem so that S4's calculation was right. This explains that S4 is weak in verbal representation ability.

Concrete Random (CR) Students

The scores and predicates for subjects S7, S8, and S9 of CR category were shown in **Table V**. Results told that the representation ability of CR students is on sufficient predicate for the visual and verbal representation, and is on bad predicate for the symbolic representation.

TABLE V. Results of CR students

Indicator	Overall score	Predicate
Visual	74.9%	Sufficient
Verbal	61.6%	Sufficient
Symbolic	57.9%	Bad

The results for the visual representation ability of CR students were evaluated sufficiently from three subjects. Here **Figure 7** showed the answer of S7 for item number 9. S7 could represent the construction visually accurately. S7 could label the rectangular prism measurement as the question asked. S7 used the multiple ratios 2 as the original ratio, that is 6:4:2.

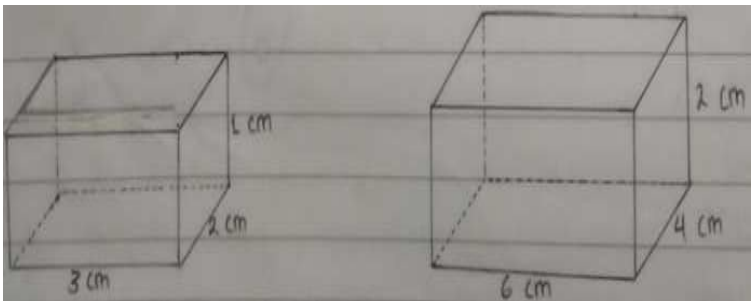
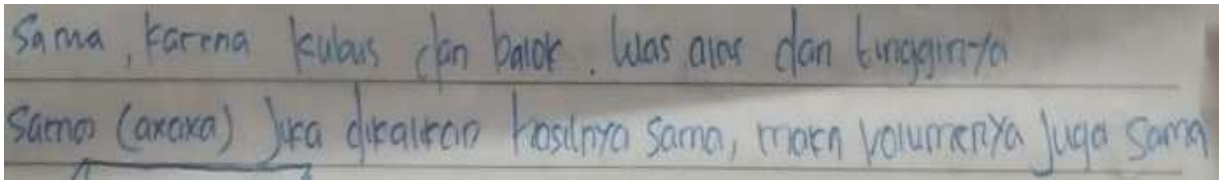


FIGURE 7. The answer of S7 on test item number 9

From the interview, S7 said that the ratio 3:2:1 means that the multiple 3 for length, the multiple 2 for width, and the multiple 1 for height. S7 furthermore explained that the rectangular prism could be changed as the following size, 6 for length, 4 for width, and 2 for height. As long as the ratio is 3:2:1, the rectangular prisms could be similar shapes.

The CR students for verbal representation ability could answer the test representation ability also sufficiently. The solution that was presented by S8 can be seen in **Figure 8**. S8 as one of the CR students gave an explanation verbally correctly for the item number 2.



Translation:
"They are the same in size because the cube and the rectangular prism have the same size in the base area and the height (a x a x $a = a^3$). If the base area and the height are multiplied and the results for both solid geometry shapes are the same, then the volume will also be the same size".

FIGURE 8. The answer of S8 on test item number 2

From the interview, S8 could explain the process of S8's reasons to get the conclusion. S8 also could furthermore generalize the statement from the multiplication of the base area and the height to the volume of both the cube and the rectangular prism.

For the results of CR students, their scores were bad in symbolic representation ability in contrast to other representation abilities from the overall score. S9 actually could solve the problem sufficiently, here for the item number 7 in **Figure 9**, but S9 could not use the symbolic representation ability properly. S8 could not decide the right formula for solving the problem, because S8 only used the reasoning and the estimation to answer it.

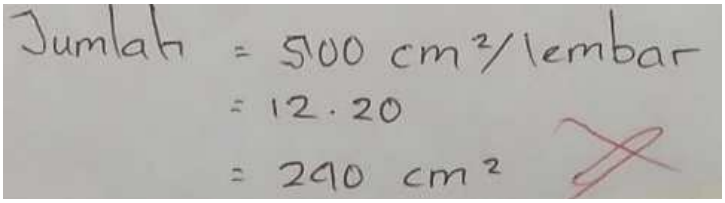


FIGURE 9. The answer of S9 on test item number 7

S8 said in the interview that S8 only the price of the pattern paper is 500 cm2/sheet where it equals "12 times 20". S8 got the value 20 from the side of the cube, but S8 got the value 12 from S8's estimation so that S8's answer went wrong. S8 used other steps that S8 learned from the teacher and it could be concluded that S8 did understand the topic of the solid geometry well enough.

Abstract Random (AR) Students

Table VI referred to the evaluation for subjects S10, S11, and S12 of the AR category. It said that the representation ability of AR students is on sufficient predicate for visual and symbolic representation, and is on very bad predicate for verbal representation.

TABLE VI. Results of AR students

Indicator	Overall score	Predicate
Visual	61.0%	Sufficient
Verbal	50.5%	Very bad
Symbolic	74.6%	Sufficient

The results of the AR students were predicated as sufficient for visual representation ability. These results come from the overall scores of the three AR students. The answer of S10 is shown in **Figure 10**. S10 created the rectangular prism with length 5, width 4, and height 5. Meanwhile, S10 created the cube with side 5. The question number 2 gave the information that the base area of both solid geometry shapes was the same in size, but S10 created both shapes in different size, "5 times 4" for the rectangular prism, and "5 times 5" for the cube.

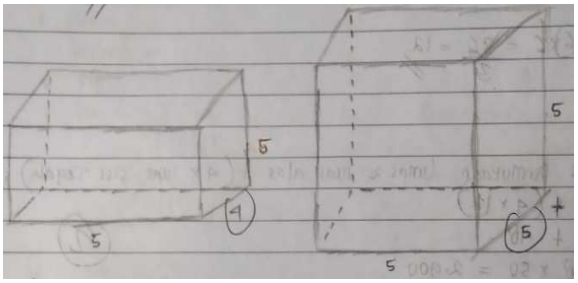
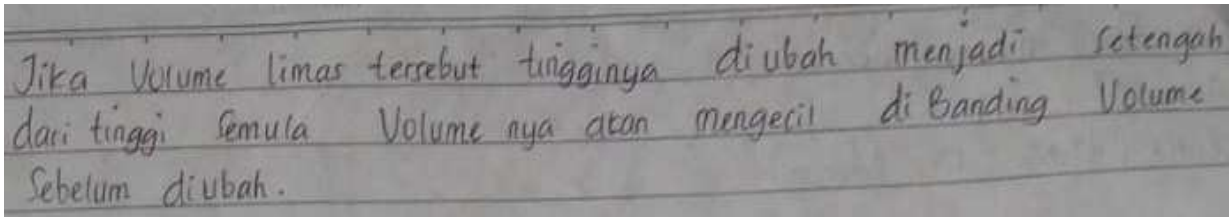


FIGURE 10. The answer of S10 on test item number 2

S10 argued from the interview that if the exact value of the length and the width is 5, then the shape will not be a rectangular prism instead of a cube. S10 also wrongly visualized the height of both shapes in different size, although S10 labeled them with the height 5. Generally, S10 did know the concept of the cube and the rectangular prism very well, so that S10 could not assume that a rectangular prism will be a cube if the length and the width are the same in size.

For verbal representation, the overall scores of AR students were very bad in the evaluation. The result of S11 for question number 4 is presented in **Figure 11**. S11 only generally elaborated on the statement. S11 could not point that the exact size after changes occurred in the height of the pyramid. In the question number 4, the original height of the pyramid is 12 cm. If the height of the new pyramid is half of the original one, then the new height will be 6 cm, but S11 could not mention it.



Translation:
"If the height pyramid is changed to half of the original one, then the volume will decrease proportionally in comparison of the original pyramid volume".

FIGURE 11. The answer of S11 on test item number 4

The overall scores of AR students were classified as sufficient predicate for symbolic representation ability. Again, here **Figure 12** is the result of S11 for the item number 6. S11 solved the problem very well and could use the right symbol to represent the data given in the question. S11 created the equation that the pentagonal prism volume was similar to the base area multiplied by the height. Then, S11 sought the three-quarter of the pentagonal prism volume to know the volume of water.

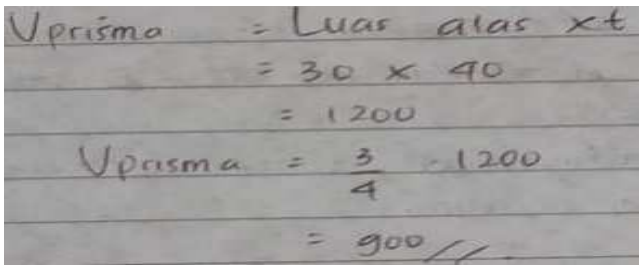


FIGURE 12. The answer of S11 on test item number 6

From the interview, S11 interpreted that the meaning of three quarter is 3 over 4 so that S11 could solve the problem quietly good. S11's symbolic representation ability is good enough, although S11 did not represent the data to a single letter for the base area.

Relation between Representation Ability and Mindy Styles

The mathematical representation ability of students could be explained by viewing the mind styles of students. As mention in previous results and discussion, the varieties of students' representation ability levels are different depending on the mind styles viewpoints. Each category has a unique classification.

The CS students dominantly mastered both visual and symbolic representation instead of verbal representation. Kholiqowati also found that the learning outcome of the CS students with both visual and symbolic representations were good at solving the problem [10]. This phenomenon happened because the CS students were more interested in the concrete object to be observed. This can be shown in **Figure 1**, **Figure 2**, and **Figure 3** that the CS students badly conveyed the solution in verbal sentences.

The AS students dominantly mastered both visual and verbal representation instead of symbolic representation. This information matched with Nugroho findings which told that students' communication aspect was good in writing and solving the problems that means the students' verbal representation was good [11]. The case occurred because the AS students were more fascinated with the abstract object to be imagined. **Figure 4**, **Figure 5**, and **Figure 6** indicated that the AS students more average to have symbolic representation ability.

The CR students generally mastered both visual and verbal representation instead of symbolic representation. This data quietly was in line with Mirfani study that the CR students were dominant in understanding the administration field which always used the writing skills or in another way the verbal representation [12]. The finding is concluded like that because the CR students were more interested in concrete objects and emotional expression to be sensed. The finding can be shown in **Figure 7**, **Figure 8**, and **Figure 9** that the CR students badly wrote the solution into the symbol representation.

The AR students generally mastered the visual and symbolic representation instead of verbal representation. This result was similar to Saminan results that the AR students dominated by 34% in solving the kinematic graphics that used the construction and symbols [13]. The result is judged like that because the AR had the experimental behavior so that fewer structure problems can be visualized and symbolized. From **Figure 10**, **Figure 11**, and **Figure 12**, the AR students could not explain their statements properly.

CONCLUSION

The research findings concluded four points. Firstly, the subjects with mind style of CS had the visual and symbolic mathematic representation ability on a sufficient predicate, but the verbal mathematic representation ability on a bad predicate. Secondly, the subjects with mind style of AS had the visual and verbal mathematic representation ability on a very bad predicate, but the symbolic mathematic representation ability on a sufficient predicate. Thirdly, the subjects with mind style of CR had the visual and verbal mathematic representation ability on a sufficient predicate, but the symbolic mathematic representation ability on a bad predicate. Fourthly, the subjects with mind style of AR had the visual and symbolic mathematic representation ability on a sufficient predicate, but the verbal mathematic representation ability on a very bad predicate.

The recommendation from this study focuses on five points. The research of mathematical representation ability viewed by the mind styles can be studied on other topics of mathematics besides the solid geometry. Then, the subject research for the following research can be more massive to deepen the detail of the phenomena. Next, the teachers should choose the teaching methods and tools that are suitable for stimulating the mathematical representation ability of students. Later, the students could habituate to solve the problems that include the variables of visual, verbal, and symbolic for the solutions. The last one, the following research could look for the right methods and strategies to upgrade students' mathematical representation ability.

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