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ANALYSIS OF MATHEMATICAL REPRESENTATION ABILITY ON PYTHAGORAS THEOREM REVIEWED FROM LEARNING STYLE OF JUNIOR HIGH SCHOOL STUDENTS

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Abstract: This study aims to determine the mathematical representation ability of class IX students with visual, auditory, and kinesthetic learning styles on the Pythagoras Theorem material at SMPN 1 (public junior high school) Gunungsari Indonesia in the 2021/2022 academic year. This type of research is descriptive with a quantitative approach. The populations in this study were all students of class IX SMPN 1 Gunungsari. The research sampling technique used purposive sampling, and the sample was class IX-H. The instruments used are learning style questionnaires, mathematical representation ability tests, and interview guidelines. The results of this study indicate that the mathematical representation ability of students with visual learning styles is 35.56% in the low category, or students have yet to be able to meet the overall visual, symbolic, and verbal representation indicators. Furthermore, the mathematical representation ability of students with auditory and kinesthetic learning styles is 49.86% and 41.87% in the medium category. Respectively, students have been able to meet the indicators of visual and symbolic representation quite well but have yet to be able to fulfill the visual and symbolic representation and verbal representation indicators.

Keywords: *Mathematical Representation Ability, Learning Style, Pythagorean Theorem*

INTRODUCTION

The Covid-19 (Corona Virus Disease 2019) pandemic, which is endemic in almost all parts of the world, including Indonesia, has caused several obstacles in implementing the education system. Education is vital to obtain for all levels of society because it has a role in creating human resources who are knowledgeable, creative, capable, independent, democratic, and responsible [1]. One of the impacts of this pandemic on the education system is the necessity for students to study online. If there is no anticipation of problems that arise in the world of education, it will decrease the quality of human resources in the future. Therefore, mastering complex material such as mathematics during a pandemic will require harder efforts for teachers and students to maintain and improve students mathematical abilities to produce graduates who can compete in the face of the times. Considering mathematics subjects will be helpful for students to have the ability to think logically, analytically, systematically, critically, and creatively as well as the ability to work together [2].

One of the competencies that students must achieve in mathematics content, according to the 2013 curriculum, is the ability to communicate mathematical ideas [3]. The thing that will train students' skills in mathematical communication is if the success of the mathematics learning process is seen in their achievement in using mathematical representations to solve problems [4-5]. Mathematical representation skills are needed to express mathematical ideas (problems, statements, definitions, etc.) in various ways. Students can present issues that are considered complicated and complex to be simpler by adjusting strategies and utilizing representations that are considered complex right [6-7].

For this reason, students can more easily understand mathematical problems and communicate their ideas if they have and improve their mathematical representation abilities. But in fact, many students still need help finding solutions to mathematical problems. The same thing also happened at SMPN 1 Gunungsari, where the mathematical representation ability of class IX students could still need to improve or be higher. Based on the results of a preliminary study conducted in class IX SMPN 1 Gunungsari, it was found that the average score of the 45 participating students was 50,7. This value is considered low, based on the Minimum Completeness Criteria (MCC) set by the school, which is 77 for mathematics. The results of the assessment are carried out based on the student's ability to represent the problems given into three types of representation, namely 1) verbal representation, stating the problem verbally or in writing, 2) visual representation in the form of pictures, diagrams or graphs, and the like, and 3) symbol representation in the form of numbers, operation signs, algebraic symbols, and related formulas [8].

The preliminary study results also show that there still needs to be a greater understanding of students in applying the concept of the Pythagorean Theorem and presenting it correctly. In contrast, this material will be found in many problems related to triangles and quadrilaterals. For this reason, it is necessary to master this material, especially how to present the problem,

which is the basis before entering into more complex material.

During the PLP program (Pengenalan Lapangan Persekolahan) at SMPN 1 Gunungsari, the students' low mathematical representation ability was caused by the ineffectiveness of the teaching and learning process during the Covid-19 pandemic. According to the mathematics teacher, only a few students participated in online learning by asking questions, doing sample questions, and collecting assignments. The most common reasons were also conveyed that the conditions and facilities were not supported when studying online and the difficulty in adapting to the current way of learning and adapting to student learning habits. In addition, students rarely do assignments requiring precise steps and solve problems in a structured and systematic way. Whereas, to measure the level of students' understanding when learning online, it can be seen from their mathematical representation ability because it will be easier to assess by paying attention to how students solve problems from the tasks that have been given, which are presented in writing.

Not only during online learning, but many students also need help understanding mathematics lessons even though face-to-face learning is carried out. It is because students need to recognize themselves and have the right learning strategies to do consistently. In addition, teachers in schools tend to teach conventionally, and it is still difficult to determine the right learning method, so there are still many students whose grades still need to be completed. In line with the problems that occur, it is stated that almost all students with low achievement have to learn styles that are not in accordance with the way teachers teach in schools [9]. Learning style is a person's way of absorbing, organizing and processing information or learning materials easily, consisting of three types: visual, auditory, and kinesthetic [10]. According to Bandler and Grinder, almost everyone has one learning style that plays a role in learning, processing, and communication [11].

Mathematical representation ability is related to students' learning styles. When students want to show their mathematical representation ability in solving mathematical problems, students try to recall the knowledge they got so that they get clues to find the solution [12]. The instructions obtained result from thinking and learning mathematics activities visually, auditory, and kinesthetically. Based on this statement, visual, auditory, and kinesthetic learning styles have a role in determining the level of students' mathematical representation abilities. Therefore, it is important to recognize students' learning styles to overcome problems related to their mathematical representation abilities.

RESEARCH METHODS

Based on the level of explanation, this research is descriptive research with a quantitative approach. This type of quantitative descriptive research aims to obtain more in-depth information on a phenomenon so that it can be described as representative and as it is using the stages of research with a quantitative approach [13].

The populations in this study were all students of class IX SMPN 1 Gunungsari. The population is a collection of all members or elements that form a group with clear characteristics, either in the form of people, objects, or other elements [14]. The sample selection technique is done by purposive sampling. Selecting samples based on the consideration that students have finished studying the Pythagorean Theorem material, communicative, and from classes with standard mathematical abilities. The sample is part of the number and characteristics possessed by that population [15].

Data collection techniques and instruments used were learning style questionnaires, representation ability tests using the Pythagorean Theorem, and interview guidelines. The three instruments were tested for content validity by two experts whose results were calculated and analyzed using the Aiken Validity formula, $V = \frac{\sum s}{[n(c-1)]}$ with description, V: Aiken Validity index, *r*: the score is given by validator, *lo*: lowest score, *s*: $r - lo$, *c*: highest score, and *n*: number of validators [16]. The instrument is declared valid if the minimum validity is 0,60 [17].

The data analysis process begins by analyzing the tendency of students' learning styles based on the answers to the questionnaire. Determination of student learning style tendencies can be done by the researchers themselves [18]. The following conditions apply: a) If one of the learning style scores is the highest score, then the student is classified as having the highest type of learning style; b) If there are two types of learning styles with identical and highest scores, then the student is classified as having a combination type of learning style; and c) If the scores of visual, auditory, and kinesthetic learning styles are the same, then the student is classified as a type of visual-auditory-kinesthetic learning style.

The next step is to analyze the data on the results of the student's mathematical representation ability test on the Pythagorean Theorem material based on mathematical representation indicators, including 1) presenting the problem in the form of a geometric image and writing down the known elements in the image, 2) presenting problems by making equations or mathematical models from other representations given and can use the right formula, and 3) write the steps for solving the problem in the form of

written text or words and can write conclusions. After calculating the mathematical representation ability score, students are classified into three categories.

Table 1 Category of Mathematical Representation Ability

Score (%)	Category
70 – 100	High
39 – 69	Medium
0 – 38	Low

Furthermore, two students were selected from each learning style as interview subjects to obtain more in-depth information on the level of mathematical representation ability in the Pythagorean Theorem material in terms of student learning styles.

RESULTS AND DISCUSSION

Before being given to students, the instruments used to obtain data on the tendency of learning styles and students' mathematical representation abilities have been validated by experts. It is done so that the instrument used can produce representative data.

Furthermore, a learning style questionnaire consisting of 21 statements was filled out by 28 students in grades IX-H. Each answer chosen by students has been given a score to obtain the following results.

Table 2. Learning Style Frequency Distribution

Learning Style	Frequency	Percentage
Visual	10	35.71%
Auditory	10	35.71%
Kinesthetic	7	25%
Visual-Kinesthetic	1	3.57%
Total	28	100%

Based on Table 2 above, the results show that students' learning styles in class IX-H are quite diverse. The visual and auditory learning styles group became the group with the most members, followed by the kinesthetic learning style group and the visual-kinesthetic combination.

The mathematical representation ability test is given consisting of 2 questions and uses the Pythagorean Theorem material. Each question contains an assessment that refers to 3 representation indicators that have been adapted from representation indicators according to Villegas & Gutiérrez, namely 1) visual representation, presenting problems in the form of pictures and writing down the elements, 2) symbolic representation, presenting problems using parables into symbols and apply the right concept, and 3) verbal representation, writing the steps of solving problems in a structured way into words [10]. Based on the analysis that has been done, the following results are obtained.

Table 3. Students' Mathematical Representation Ability

Score (%)	Frequency	Percentage	Category
70 – 100	4	14.3%	High
39 – 69	7	25%	Medium
0 – 38	17	60.7%	Low
Total	28	100%	

Table 3 shows that the number of students with mathematical representation abilities in the low category is more than the number of students in the high and medium categories. That means that most of the class IX H students still have difficulties and need help understanding how to present mathematical problems appropriately.

After seeing students' mathematical representation abilities in general, the following is presented the ability of each type of learning style on each indicator of mathematical representation.

Table 4. Category of Mathematical Representation Ability per Indicator for Each Learning Style

Learning Style	Visual Representation Percentage	Category	Symbolic Representation Percentage	Category	Verbal Representation Percentage	Category
Visual	51.67	Medium	33.75	Low	21.25	Low
Auditory	68.33	Medium	63.75	Medium	17.50	Low
Kinesthetic	71.43	High	42.86	Medium	16.07	Low

Table 4 shows that each learning style group obtained the highest average percentage on the visual representation indicator and the lowest on the verbal representation indicator. It shows that each learning style group tends to be easier to understand and present problems visually (pictures) and with verbal difficulties (words). In addition, it was also shown that there was no difference in verbal representation skills which were in the low category, namely not being able to write

problem-solving into words, such as writing down information that was known and asked, explaining the meaning of the parables used, and writing appropriate conclusions. These results are in line with previous research. Namely, the three study groups also did not have differences in the achievement of verbal representation abilities, which were both the lowest compared to the other two representation indicators [19].

Table 5 Overall Category of Students' Mathematical Representation Ability in Each Learning Style

Learning Style	Averages (%)	Category
Visual	35.56	Low
Auditory	49.86	Medium
Kinesthetic	41.87	Medium

Table 5 shows that the overall results of students' mathematical representation tests in the auditory and kinesthetic learning style groups have the same mathematical representation abilities. In the medium category or have been able to present problems in geometric form and apply the right formulas and concepts but have yet to be able to make work steps. Meanwhile, the students with visual learning styles have low mathematical representation skills or need help to describe problems in geometric form, write equations, apply formulas and concepts, and make proper working steps.

Students' Mathematical Representation Ability with Visual Learning Style

Based on the results of the data analysis presented in Table 5, students with visual learning styles are in the low category on the mathematical representation ability test [12]. The group of students with a visual learning style has the lowest percentage among the auditory and kinesthetic learning style groups. Visual students need help understanding the material used in the test, namely the Pythagorean theorem. In addition, visual students must present the problems given in three forms of representation at a time.

In the medium category indicator of visual representation ability, it was found that some visual students could draw flat shapes and write down and place every known size on the image made correctly. It shows that students with visual learning styles tend to absorb learning/information through visualization delivered by the teacher, such as when giving examples of questions, practice questions, or tests. Even so, students with the visual learning style group still need to gain good visual representation skills. Visual representation skills tend to be owned by students with visual learning styles [20].

Of the ten visual students, seven still need help presenting images in a complete geometric form and writing and placing the known measurements according to the problem. It is due to the need for more accuracy of students when reading and understanding the meaning of these questions. These results differ from visual students' characteristics, namely meticulous to detail [21]. These results can be caused by the characteristics of visual students, who can also sometimes lose concentration when they want to pay attention or understand something. As is known, in the current condition, students study more at home independently, thus making it difficult to concentrate and understand the content of the subject matter. In addition, it can be caused by the lack of intensity of learning time which is directly explained and given notes by the teacher.

In the indicator of the ability of symbolic representation in the low category, it was found that most visual students could not write or give parables that matched the existing problems and wrote or applied the right formula. It is because students are often less careful in writing symbols in formulas, need more understanding of material concepts so that they misuse formulas, and do not make parables with symbols to name known and asked sides. Some students often need to remember how to solve problems with symbols and most students cannot answer because they need help understanding the meaning of the questions [22]. The ability of mathematical representation (symbolic) with a low category also shows the inability of students to make examples of problems into mathematical symbols [23]. Visual students can interpret problems in mathematical sentences and perform calculations with the mathematical sentences they make [24].

The indicator of verbal representation ability is in a low category. It is found that almost all visual students cannot write down the information that is known and asked or the steps for solving it into words, write down the information that needs to be conveyed and draw conclusions correctly. In fact, there is already an order to write down the steps for doing it on every given mathematical representation test question. Students in the low-category mathematical representation ability group have yet to be able to involve written sentences to solve problems [23]. It is because solving problems using words (verbal) is rarely encountered by students in daily learning, and they also need help understanding the meaning of the questions. The verbal representation ability of students with visual learning styles is in line with their characteristics. Namely they are not good at choosing words [27]. The lack of writing examples of appropriate presentations and the emphasis on the importance of verbal representation in learning make it difficult for visual students to remember how to write problem-solving in their own words.

Students' Mathematical Representation Ability with Auditory Learning Style

Based on the results of the data analysis presented in Table 5, the auditory learning style group of students obtained the highest average on the mathematical representation test among the visual and kinesthetic learning style groups, which was 49.86% in the medium category. The group of students with an auditory learning style has the highest percentage among the auditory and kinesthetic learning style groups [12]. This learning style group can be the group with the highest test scores because mathematics learning often uses a cooperative learning model, namely discussing with group friends. It is quite helpful for auditory students in learning because it matches the characteristics they like to discuss [27]. Even so, being in the medium category indicates that some students still get low test results.

In the medium category indicator of visual representation ability, it was found that some of the auditory students were able to describe flat shapes and write down and place every known measure on each image element correctly according to the information on the test questions. However, some auditory students have yet to be able to fulfill the visual representation indicators as a whole. Of ten students with auditory learning styles, three can fulfill all visual representation indicators. Four students still need help meeting the visual representation indicators. Mistakes that occur, such as not describing the elements that are known correctly and placing the wrong size according to the shape of the image made. Students with an auditory learning style are often negligent in writing down the elements in the pictures they make [26]. It is in accordance with the characteristics of students with auditory learning styles, namely, having problems with work that involves visualization [27].

In the indicator of symbolic representation ability which is classified as medium, it was found that some auditory students could write or give parables that matched the existing problems and wrote or applied formulas correctly. The average value obtained for this indicator is slightly lower than the average value for the visual representation indicator. Two students have been able to fulfill all the indicators of symbolic representation, four students still have errors, and four other students still need to be able to meet the indicators of symbolic representation. Small things that become student errors should be paying attention and writing down the formulas used correctly, such as the lack of rank symbols, brackets, and the accuracy of the calculation process even though the answers produced are correct. The results of the written test of students with auditory learning styles need to be corrected in writing some symbols or mathematical notation [25]. Meanwhile, four students who got low scores showed a lack of understanding of solving problems such as not writing down the names of the known sides, not writing down formulas that match the problem, and needing to complete calculations correctly. Some auditory students still need to be able to relate the problems given with appropriate concepts and methods [24]. It is because auditory students prefer to learn something by discussing it. Mathematics material contains many symbols or notations whose writing procedures cannot be learned by simply listening to others explain or discuss [25].

The indicator of verbal representation ability is in a low category. It is found that almost all auditory students need help to write down the information that is known and asked or the steps for solving it into words, write down the information that needs to be conveyed, and correctly draw conclusions. Of ten students with auditory learning styles, only one writes known things and asks the conclusion into words even though it is a little less precise. It shows that auditory students cannot determine the steps for solving problems, such as determining what is known and asked [23][24]. Students with an auditory learning style can correctly write down the steps and conclusions [26].

Students' Mathematical Representation Ability with Kinesthetic Learning Style

Based on the results of the data analysis presented in Table 5, students with kinesthetic learning styles are in the medium category on the mathematical representation ability test. This group obtained the second-highest average percentage after the group of students with auditory learning styles. The group of students who have a kinesthetic learning style has the second-highest percentage of the visual and auditory learning style group [16]. This learning style group can get the second-highest test score after the auditory learning style group because kinesthetic students are quite benefited from learning that currently applies a scientific approach, such as carrying out experimental or practical activities. Currently, textbooks are more instructing students to observe and then try to find solutions to the problems observed. It can be quite helpful for kinesthetic students to acquire knowledge because it is in accordance with their characteristics that they like to learn through manipulation and practice [27]. Even so, being in the medium category indicates that some students still get low test results.

In the indicator of visual representation ability in the high category, it is found that most kinesthetic students are able to draw flat shapes and write down and place every known size on the image that is made correctly. Of seven students with kinesthetic learning styles, one

student has been able to fulfill all the indicators of visual representation, four students still have errors, and two other students still need to be able to meet the indicators of visual representation. Errors include not describing the geometric shape that matches the given problem or not correctly writing the known side sizes on the drawing. Meanwhile, the two students who got low scores did not present the object of the problem in the right flat shape, and there were also unresolved pictures. However, Students can write complete information and visualize a problem correctly based on the information in the question [25]. It shows that kinesthetic students tend to be skilled in changing things using their hands or tools to make it easier for them to understand the problem, in this case describing well the known object.

On the indicator of the ability of symbolic representation, which is categorized as a medium, it is known that some students have been able to write or give parables matched with the existing problem and write or apply the right formula. The student can use symbols, notations, and mathematical equations for learners with kinesthetic learning styles in the medium category. Three kinesthetic students have fulfilled the symbolic representation indicator even though there are still errors and four other students still need to fulfill it. In contrast to the results of previous studies, most students in this category need help in making mathematical models that involve problem-solving, making it difficult to find the right solution [23-24]. Students need to pay more attention and write down the formulas used correctly. The lack of rank symbols, brackets, the accuracy of the calculation process even though the answers are correct, not making analogies with known side names, or not applying the right formulas. During learning during the pandemic, students are increasingly being given practice questions, or activities teachers carry out to find solutions to a problem. Moreover, not all students can try to do each of the activities instructed in their textbooks. Based on the characteristics of the kinesthetic student learning method, namely learning through manipulation and practice [27], the tendency of the learning method is less applicable.

The indicator of verbal representation ability is in a low category. It is found that almost all kinesthetic students need help to write down the information that is known and asked or the steps for solving it into words, write down the information that needs to be conveyed and draw conclusions correctly. The value of this group is also the acquisition of the lowest average verbal representation ability among the visual and auditory learning style groups. Students with low representation ability cannot use words to solve a problem [23]. Errors that occur are not writing down things that are known and asked, steps, and conclusions from problem-solving into words. The same results were also obtained in previous studies. Namely, students with kinesthetic learning styles needed to write down known information and were asked completely and with the right conclusions [24][26].

CONCLUSIONS

The mathematical representation ability of students with visual learning styles is 35.56% and is in the low category, or in detail, it is in the medium category on the visual representation indicator and the low category on the symbolic and verbal representation indicators. It shows that visual students have yet to adequately fulfill the overall visual, symbolic, and verbal representation indicators. Furthermore, the mathematical representation ability of students with auditory and kinesthetic learning styles was 49.86% and 41.87%, respectively, in the medium category. Auditorial students are in the medium category for the achievement of visual representation indicators. However, auditory and kinesthetic students were in the medium category for achieving symbolic representation indicators and low for verbal representation indicators. It shows that auditory and kinesthetic students have been able to meet the indicators of visual and symbolic representation quite well but have yet to meet the indicators of verbal representation.

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