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Exploring Students' Visualization Skills concerning Learning Styles

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Abstrak

Kemampuan visualisasi merupakan aspek krusial dalam memahami materi dimensi tiga. Tujuan penelitian ini yaitu menggambarkan kemampuan visualisasi siswa sekolah menengah atas dalam pembelajaran materi dimensi tiga berdasarkan gaya belajar. Subjek penelitian kualitatif ini dipilih dengan metode purposive sampling. Teknik pengumpulan data menggunakan tes essay berdasarkan indikator ketrampilan visualisasi. Teknik analisis data meliputi pengumpulan data, kategorisasi data, penyajian data dan penarikan kesimpulan. Hasil penelitian menunjukkan kemampuan visualisasi siswa berbeda berdasarkan gaya belajar. Siswa dengan gaya belajar visual menunjukkan kemampuan visualisasi yang sangat baik yaitu menyelesaian masalah, pencarian pola, pengonsepan, pengimajinasian, dan memvisualkan. Siswa dengan gaya belajar auditori menyelesaikan masalah, pencarian pola, dan memvisualkan, namun belum optimal dalam pengimajinasian dan pengonsepan. Siswa dengan gaya belajar kinestetik menyelesaian masalah dan pencarian pola, sedangkan mengimajinasikan hanya tercapai sebagian, dan pengonsepan serta memvisualkan belum terpenuhi secara memadai. Temuan ini menunjukkan adanya hubungan erat antara gaya belajar dan pencapaian kemampuan visualisasi dalam memahami materi dimensi tiga.
Kata Kunci: DImensi Tiga; Gaya Belajar; Matematika; Visualisasi

Abstract

Visualization ability is a crucial aspect in understanding three-dimensional material. The purpose of this study is to describe the visualization ability of high school students in learning three-dimensional material based on learning styles. The subjects of this qualitative study were selected using the purposive sampling method. The data collection technique used an essay test based on visualization skill indicators. Data analysis techniques include data collection, data categorization, data presentation and drawing conclusions. The results of the study showed that students' visualization abilities differed based on learning styles. Students with a visual learning style showed very good visualization abilities, namely solving problems, finding patterns, conceptualizing, imagining, and visualizing. Students with an auditory learning style solved problems, finding patterns, and visualizing, but were not optimal in imagining and conceptualizing. Students with a kinesthetic learning style solved problems and searching for patterns, while imagining was only partially achieved, and conceptualizing and visualizing had not been adequately fulfilled. These findings indicate a close relationship between learning styles and the achievement of visualization abilities in understanding three-dimensional material.
Keywords: Learning Styles; Mathematics; Three Dimensions; Visualization

I. INTRODUCTION

Visualization is a very important ability in learning mathematics (Giyanti & Oktaviyanthi, 2024), especially in relation to learning materials where problems are solved in visual form, such as three-dimensional materials and geometry. The reality in the field is that not all students can understand learning material through visuals or by seeing, but there are also students who understand it through hearing and movement. This is because each individual student has a different learning style and level of ability. So, the aim of this research is to see the extent of students' visualization abilities in third-dimensional learning in terms of learning style.

Visualization is the mental act of representing visual information (Presmeg, 2006; Yurmalia & Herman, 2021),. Visualization is one of the abilities that every student must have in learning mathematics, because in learning mathematics not all mathematical problems tend to be solved analytically, but can also be solved visually, such as material related to learning geometry, three dimensions, and so on. Visualization ability is the ability to understand or solve a problem in visual form, such as maps, pictures, graphs, and so on (Schoenherr & Schukajlow, 2024). In solving mathematical problems that require thinking from abstract to concrete to understand them, visualization skills are very necessary (Hermiati et al., n.d.). This is because the objects in mathematics learning are not always in concrete form but are abstract in nature that can be imagined in the minds of students (Adnyana et al., 2021).

In mathematics, visualization refers to the skill, process, and outcome of generating, understanding, applying, and evaluating images, sketches, or diagrams—whether mentally, on paper, or through digital tools—to represent and convey information, explore concepts, and develop ideas, previously unknown to expand understanding (Rösken & Rolka, 2006; Muniri & Yulistiyah, 2022). By visualizing problems in mathematics, the meaningfulness of mathematical concepts can be explored, and the relationship between the two, especially when faced with a lot of incoming information, through visualization complex problems can be reduced (Rösken & Rolka, 2006; Sarumaha et al., 2024). One of the learning materials whose problem solving requires visualization skills is three dimensions.

The ability to visualize in three-dimensional learning includes determining the distance between two points, calculating the distance from a point to a line segment, and finding the distance from a point to a plane. A student's learning style plays an important role in helping them grasp this material effectively. Learning styles refer to the cognitive, emotional, and psychological traits that consistently influence how students perceive, engage with, and react to their learning environment (Aljaberi, 2015; Ali, Lestari, & Rahayu, 2023; Rahmayani, Susanto, & Suwito, 2023). Learning styles relate to how students obtain, absorb, understand, and process existing information (Sujadi et al., 2019; Delima et al., 2019; Ocampo et al., 2023; Noto et al., 2023).

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Learners' learning styles also determine how they respond to stimuli in the learning context (Cardino & Ortega-Dela Cruz, 2020). Therefore, in learning mathematics, a teacher needs to pay attention to the learning styles of his students. This occurs because academic achievement tends to improve when instruction aligns with students' individual learning styles and when students are aware of and apply their own preferred ways of learning (Bosman & Schulze, 2018). According to several learning theories, there are two prominent models of learning styles: VAK (Visual, Auditory, and Kinesthetic) and VARK (Visual, Aural, Read/Write, and Kinesthetic) (Yorganci, 2018). In mathematics learning there are three types of learning styles that are often used, namely visual, auditory and kinesthetic (VAK) (Asmarawati & Pramesti, 2019; Fadilah et al., 2023; (Sanatil Hijriati et al., 2024). This is because the VAK learning style is easier to identify a person's learning style and is more well known (Jordan & Levine, 2009; Kartina & Afriansyah, 2024). Thus, it is necessary to carry out research related to the analysis of students' visualization abilities in three-dimensional learning. The problem formulation in this research is what is the profile of students' visualization abilities in three-dimensional learning based on learning styles.

Visualization in mathematics learning plays a very important role, especially in relation to materials where some of the problem solving is in visual form, such as three-dimensional geometric shapes. According to Presmeg, visualization is one of the main research areas in the study of mathematics education. According to Bishop, this is because visual representations are very helpful, especially abstract indications in mathematics, so that when students are faced with mathematical concepts, things that are not physically present need to be considered. So to be able to see how students' visualization abilities are in three-dimensional learning, it is necessary to pay attention to students' learning styles.

The learning styles needed here are visual, auditory and kinesthetic learning styles. Visual learning style is a learning style where the most effective learning situation is when seeing pictures, colors, diagrams of what they are studying (Sword, 2005; Machromah et al., 2021),Click or tap here to enter text.. The auditory learning style is a learning style where the most effective learning situation is when hearing what they are learning (Rahman & Ahmar, 2017). The kinesthetic learning style is a learning style by involving oneself, moving, experiencing and experimenting (Rahman & Ahmar, 2017). Students who learn using the kinesthetic style to be able to learn optimally use more of their physical abilities (Ramadoni & Dimas, 2023). Thus, the approach used in problem solving in this research is learning style.

Visualization holds a crucial role in mathematics learning, particularly for topics that involve visually-based problem solving, such as three-dimensional geometry. Presmeg highlights that visualization is a key focus area in mathematics education research. According to Bishop, this is because visual representations are very helpful, especially abstract indications in mathematics, so that

when students are faced with mathematical concepts, things that do not exist physically need to be considered. So to be able to see how students' visualization abilities are in three-dimensional learning, it is necessary to pay attention to students' learning styles. The learning styles needed here are visual, auditory and kinesthetic learning styles. Visual learning style is a learning style where the most effective learning situation is when seeing pictures, colors, diagrams of what they are studying (Sword, 2005; Machromah et al., 2021; Mahardika, Gumilar, & Retnaningrum, 2022). The auditory learning style is a learning style where the most effective learning situation is when hearing what they are learning (Rahman & Ahmar, 2017). The kinesthetic learning style is a learning style by involving oneself, moving, experiencing and experimenting (Rahman & Ahmar, 2017). Students who learn using the kinesthetic style to be able to learn optimally use more of their physical abilities (Ramadoni & Dimas, 2023). Thus, the approach used in problem-solving in this research is learning style.

A study titled "Visual Thinking Ability of Mathematics Education Students on Geometry Transformation Learning Material" (Hermiati et al., 2021) revealed that students' thinking abilities were limited to the stages of organizing, exploring, and identifying—indicating they had only reached the levels of acquisition and reasoning. It means only the acquisition and reasoning. Another research entitled analysis of students' visual-spatial thinking abilities in learning geometric transformations (Hermiati & Julianti, 2023) The results of this study indicate that students' visual spatial abilities are still lacking, especially in the conceptualization indicator. Students tend to be more inclined towards the visual spatial ability imagination indicator. The overall level of students' visual-spatial thinking abilities in the geometric transformation material is in the moderate category with the imagination indicator being more dominantly owned by students, while for the conceptualization, problem solving and pattern finding indicators are still lacking. Students' visual-spatial thinking abilities are still low. Students still have difficulty in solving this question related to the geometric transformation material, namely translation, reflection, rotation and dilation. Visual-spatial thinking abilities are competencies that need to be developed in learning geometric transformations, one of the causes of low geometry learning outcomes is low visual-spatial thinking abilities.

II. METHOD

This study employed a qualitative research approach with the objective of describing students' visualization abilities in three-dimensional learning, viewed from the perspective of their learning styles. The research involved three 12th-grade students from SMA Maniamas Ngabang and was conducted over a three-month period, from May to July 2024. The research instruments were developed based on indicators of visualization ability and validated by experts in Mathematics Education and mathematics teachers. Participants were selected through purposive sampling. The research

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procedures included: (1) selecting participants by administering a learning style questionnaire, (2) collecting data through tests and interviews, (3) performing time triangulation and validating the data, and (4) analyzing the data. Instruments used in this study included a learning style questionnaire, a visualization task on three-dimensional material, and an interview guide.

The test instruments used in this research are visualization ability test questions number 1 and 2, which contain indicators of problem solving and pattern searching. In question number 1, students are expected to be able to determine the volume of the block and be able to determine the unit of books that can contain the block. In question number 2, students are asked to describe the nets of cubes and blocks with different patterns. Questions number 3, 4, and 5 contain indicators of conceptualizing, imagining, and visualizing.

In question number 3, students are asked to depict the cube again and write down each corner point of the triangle, then determine each line relationship contained in the cube. In question number 4, it is an indicator of imagination. Students are asked to describe a cube from a net, and then determine the distance between the lines in the cube. Question number 5 asks students to make block drawings.

The process of analyzing qualitative data involves several stages: data collection, data condensation, data presentation, and drawing conclusions. Data were initially gathered through testing. After collection, the data underwent a condensation process to simplify and focus the information. The condensed data were then presented, followed by the final stage of interpreting and formulating conclusions.

III. RESULT AND DISCUSSION

A. Result

Visualization abilities in terms of learning styles in this research will be seen from the VAK styles, namely visual, auditory, and synthetic. The following are the research results that will be described in this study, based on learning styles.

1. Visual Style

In the first indicator, namely the problem-solving indicator, the results of the tests carried out by YSK students as shown in Figure 1 above are that YSK understands the information contained in the questions, namely being able to write down what is known and asked in the questions. YSK also understands the block formula by dividing the volume of the box by the volume of the book, so that the number of books that can be contained in the box can be determined by YSK, namely 12 books. Then from the results of the interview, YSK can also understand what is known and asked in the question and how many books can fill the box. YSK also understands. So that the problem-solving indicators can be fulfilled by YSK. The results of students' work on problem-solving indicators are in Figure 1 below.

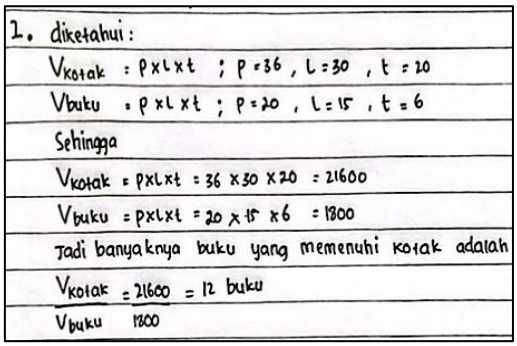

Figure 1. YSK Subject Problem-Solving Indicators

The second indicator is the search for patterns from the test results carried out by YSK, namely that YSK can describe the cube and block mesh patterns correctly, well and neatly from three different cube and block mesh patterns. Based on the results of interviews with YSK, it was found that YSK really understands cube and block nets. YSK can also explain in detail how to visualize each grid of cubes and blocks with different patterns. So, it can be said that YSK has excellent pattern search capabilities. The results of the work of YSK students can be seen in Figure 2 below.

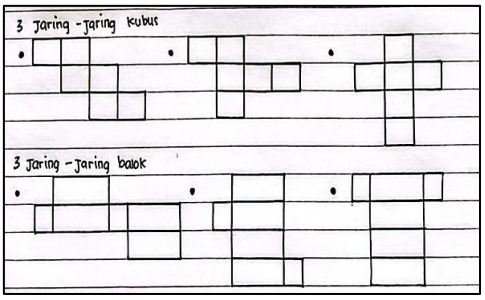

Figure 2. YSK Subject Pattern Search Indicator.

The third indicator is the conceptual indicator, based on the results of tests carried out by YSK students and the results of their interviews, it can be seen that YSK can draw the cube again correctly, and can also write down the vertex of the triangle requested in the question, namely the vertex of triangle XYZ. Meanwhile, in determining the relationship between two lines, namely the relationship between lines AB and CD, which are parallel lines, the relationship between lines BD and EG, which are lines that cross each other, and the relationship between lines AB and AE, which are lines that are perpendicular to each other, the answer is correct by YSK. Based on the results of the interview, YSK also understands the relationship between parallel, intersecting and perpendicular lines. From the test results and interview results, it can be said that YSK has a very good conceptualization in the three dimensions. The YSK students' answers to the conceptualization indicators can be seen in Figure 3 below.

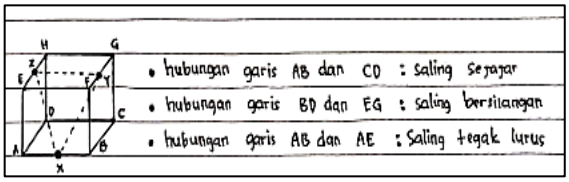

Figure 3. YSK Subject Conceptualization Indicators

The fourth indicator is the imagination indicator, based on the test results, the answer to the test carried out by YSK students is that they can depict the shape of a cube again accurately and correctly from a cube net, and can determine the distance between line BG to line AH and the distance from line EG to plane ABC, namely 30 cm. Based on the results of the interview, it can also be seen that YSK really understands the shape of the cube image from the nets that have been determined. So YSK can be said to have a very good level of imagination. YSK's answer to the imagination indicator can be seen in Figure 4.

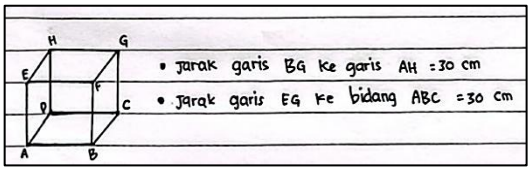

Figure 4. YSK subject's Imagination Indicator

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The fifth indicator is visualizing, from the test results carried out by YSK students, they are able to describe the shape of blocks beautifully, neatly and correctly according to the question instructions. So that the visual indicators can be fulfilled by YSK properly. Likewise with the results of the researcher's interview with YSK, the answer is very linear with the results of the tests carried out, to be able to see the results of YSK students' work on the visual indicators shown in Figure 5 below.

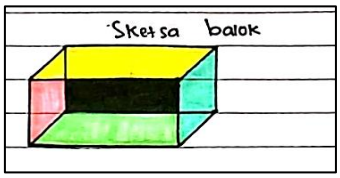

Figure 5. YSK subject's Visualizing Indicator

2. Auditorial Style

Visualization abilities in terms of auditory learning style are found in the test results of YRV students. In the problem-solving indicator based on test results, YRV students can answer the questions correctly, namely the number of books that can fit in the box is 12 books. It's just that YR didn't write down the process of getting the number of books that could contain blocks, but based on the interview results, YRV had a good understanding of the block volume formula.

On the pattern search indicator, YRV students were able to describe nets of cubes and blocks with different patterns correctly, even though the nets depicted by the subject were not very neat. Based on the results of the interview, YRV was also able to understand cube and block nets well. So that the pattern search indicator can be fulfilled by YRV. The results carried out by YRV are shown in Figure 6.

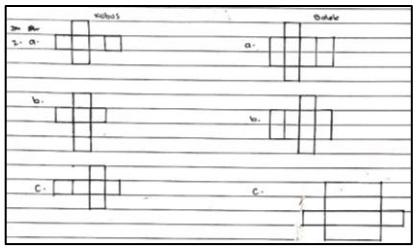

Figure 6. YRV Subject Pattern Search Indicator

For conceptual indicators, YRV can draw the cube again correctly and write each corner point of the triangle in the cube. However, in determining the relationship between lines, a mistake was made by the subject YRV, because the term line relationship was written incorrectly, then from the interview results, YRV also did not really understand the terms in relationship between lines, so from the test and interview results, it could be said that YRV did not too good at conceptualizing. The test answers carried out by YRV are as shown in Figure 7 below. For conceptual indicators, YRV was able to draw the cube again correctly and write down each vertex of the triangle in the cube. However, in determining the relationship between lines, a mistake was made by the subject YRV, because the term line relationship was written incorrectly, then from the interview results, YRV also did not really understand the terms in relationship between lines, so from the test and interview results, it could be said that YRV did not too good at conceptualizing. The test answers carried out by YRV are as shown in Figure 7.

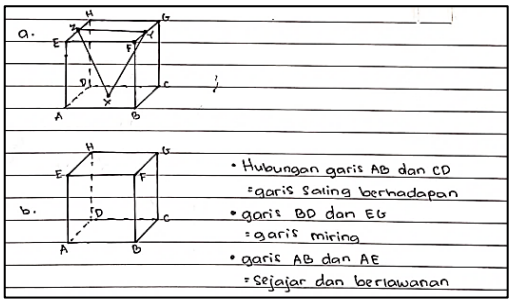

Figure 7. YRV Subject Conceptualization Indicators

In the imagination indicator, the test answers produced by YRV students were that they were able to draw the cube again correctly from the known cube mesh pattern, but in determining the distance between the lines contained in the cube, YRV made a mistake in calculating. Based on the results of the YRV interview, the subject also understands how to describe a cube from the specified cube mesh pattern, but still does not understand how to determine the distance between the lines. So, from the test and interview results, YRV is quite good in terms of imagination indicators, which means it still needs to be improved. The results of the test carried out by the YRV subject are shown in Figure 8 below.

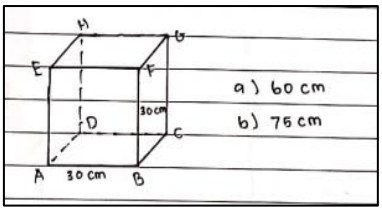

Figure 8. YRV Subject Imagination Indicator

The results of YRV students' work on the visualizing indicator were very good, YRV was able to describe the image of a cube block according to the question instructions. So it can be said that YRV visualized very well and was in sync with the answer when the subject was interviewed about how he described the block. The answer to the YRV test on the visualizing indicator can be seen in Figure 9 below.

Figure 9. Indicator Visualizing YRV Subjects

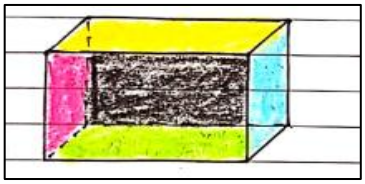

Figure 9. YRV subject's Visualizing Indicator

3. Kinesthetic Style

Visualization abilities in terms of the kinesthetic learning style can be found in the following description of the JAP student test results. In the problem-solving indicator, the answer produced by JAP students is correct, where JAP can determine the number of books that can contain the box, namely 12 books, only information related to the volume of the blocks in the problem is not written down by JAP. Based on the results of the interview, JAP can understand what is known and asked in the questions. Although information regarding what is known and asked in the question is not written down. From the results of these tests and interviews, JAP has good problem solving, as in Figure 10 below.

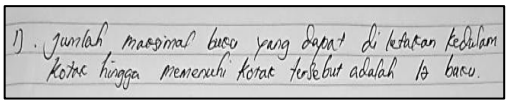

Figure 10. JAP Subject Problem-Solving Indicators

The pattern search indicator for the test results carried out by JAP students is satisfactory, this is because JAP can describe cube and block nets with different patterns precisely and correctly. Based on the results of the interview, JAP subjects were also able to understand what is

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meant by cube and block nets and could explain in detail how to visualize each cube and block net with different patterns, as shown in Figure 11 below.

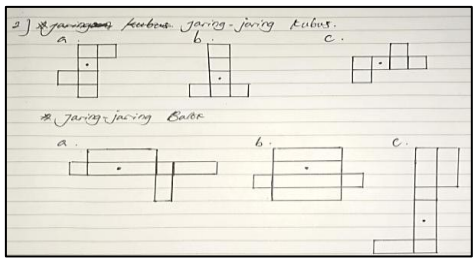

Figure 11. JAP Subject Pattern Search Indicator

In the conceptual indicators, based on the results of tests carried out by JAP students, namely JAP students can describe the cube again correctly and can determine the corner points of triangles on the cube, but in determining the relationship between each line based on the test results and interviews, JAP does not understand. because the terms of the relationship between lines written by JAP are not quite accurate. So, in terms of conceptualization indicators, JAP has not fully met the conceptualization indicators, and the results of the tests carried out by JAP are shown in Figure 12 below.

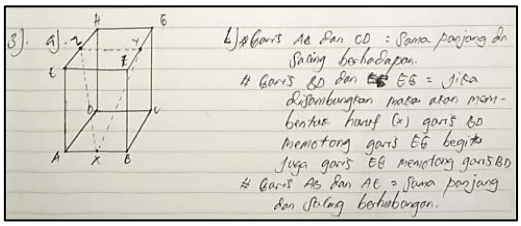

Figure 12. JAP Subject Conceptualization Indicators

In terms of imagination, JAP students do not have good imagination. This can be seen from the test results carried out by JAP, where the images created are individual cube nets, not cube images which according to the question's instructions are to create a cube image based on the specified net pattern, resulting in the specified cube distance being incorrect. . Although based on the results of the interview, JAP can actually describe the cubes of these nets. From the results of these tests and interviews, it can be seen that JAP has not yet optimally met the conceptual indicators, so it needs to be sharpened again. The results of JAP's work on the imagination indicators are as shown in Figure 13 below.

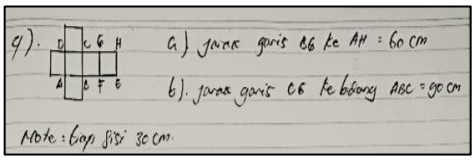

Figure 13. JAP Subject Imagination Indicators

In the visualizing indicator, the result of the test carried out by JAP is that the image of the blocks is not quite right, it can be seen from the mesh of the blocks where color information is added. If they are combined into one single block, the resulting color of a block image does not match the question command. requested. Based on the results of the interview, JAP also does not understand the position of each side which has been assigned a color. The results carried out by JAP can be seen in Figure 14 below.

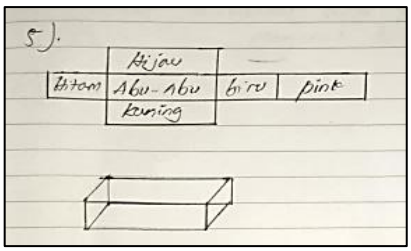

Figure 14. JAP Subject Visualizing Indicators

B. Discussion

Visualization is a key element in mathematical thinking and across various fields of mathematics. Within the mathematics education community, there

is broad agreement that visualization significantly contributes to conceptual understanding, reasoning, problem solving, and the process of proving (Fetzer et al., 2024). In three-dimensional learning, high levels of visualization are required to understand it because of its abstract nature (Bintoro, 2021). Therefore, in this research, to be able to see how students' visualization abilities are viewed from learning styles, one of them will be seen based on Haas' theory, namely that students are said to have visualization abilities if the students fulfill the indicators of imagining, conceptualizing, solving problems, and searching for patterns. (Dwi et al., 2021). Meanwhile, research conducted by (Utomo et al., 2018) shows that students who have visualization skills can fulfill the indicators, create images (visualize), examine images, scan images and transform images. Based on the two theories above, in this research, students are said to have visualization abilities, if they fulfill five indicators, namely problem solving, pattern searching, imagining, conceptualizing, and visualizing. So from the description of the research results above, visualization abilities based on learning styles are as follows.

In the visual learning style, students are able to solve problems, are very understanding in searching for different patterns, when imagining and determining the distance of an object they can be said to be very good, and have a very good concept of space, so they can describe objects well. Meanwhile, students with an auditory learning style have quite good problem solving and are very good at describing different object patterns, but it is indicated that students' imagination and conceptualization do not really understand, because they are still wrong in determining the relationship between lines and distances, but they are very good at visualizing. Students in the kinesthetic learning style only reach indicators of problem solving and pattern searching, in imagination students cannot express the relationship between lines correctly, while in conceptualization students in the kinesthetic style really do not understand the concept, where students cannot describe an object. The cube returns correctly from a net, so it has an effect on visualizing.

From this discussion, it was found that there are differences in visualization abilities between visual, auditory and synthetic learning styles in that students' visual learning styles can fulfill all indicators, both from problem solving, pattern searching, imagining, conceptualizing and visualizing. Students with an auditory learning style only fulfill three indicators, namely problem solving, pattern searching, and visualizing. Meanwhile, the indicators of conceptualization and imagination of students' auditory style are not yet optimal so they need to be further improved, which means there is a possibility of having maximum visualization abilities if they are sharpened again. In the synthetic style, it can be seen that students only fulfill one indicator, two indicators are half fulfilled and the other two indicators are not fulfilled. It can be seen that students with a kinesthetic style do not have good visualization skills.

IV. CONCLUSION

From the explanation above, it can be concluded that visualization abilities, when viewed based on learning styles, show the following pattern: students with a visual learning style demonstrate strong visualization skills, as evidenced by their test results, which fulfill all the established indicators. Good indicators of problem solving, searching for conceptual patterns, imagining, and visualizing. Students with an auditory learning style only fulfill three indicators of visualization ability, where only the indicators for problem-solving, pattern searching, and visualizing are filled. Meanwhile, the indicators of imagination and conceptualization have not been optimally fulfilled by subjects with an auditory style. Students with a kinesthetic style do not fulfill the indicators of conceptualizing and visualizing, only fulfilling the indicators of problem-solving and pattern searching. Meanwhile, the imagination indicator is half fulfilled by kinesthetic style students. Thus, the participants' visualization abilities reviewed in terms of learning styles are very good in the visual learning style, because they meet all the indicators; good for the auditory learning style, because it only meets three indicators; quite good for the kinesthetic learning style, because it only meets two indicators.

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