Analysis of mathematical inductive reasoning ability reviewed from student learning styles in mathematics learning

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Abstract: The purpose of this study is to describe students’ mathematical inductive reasoning ability viewed from visual, auditory, and kinesthetic learning styles in the Sequence and Series material. The type of research used is descriptive research with a qualitative approach. The instruments of this study were mathematical inductive reasoning ability tests, learning style questionnaires, and interview guidelines. The subjects of this study were six students of Class XI MIPA-2 SMA Negeri 1 Kota Serang that representing each learning style. The results showed that 1) students with a visual learning style were able to do transductive reasoning, analogies, used relationship patterns to analyze situations, compiled conjectures and could estimate answers, and they were able to explain patterns; 2) students with auditory learning styles were able to do transductive reasoning, analogies, used relationship patterns to analyze situations, compiled conjectures and could estimate answers; 3) students with a kinesthetic learning style were able to do transductive reasoning, analogies, could use relationship patterns to analyze situations and compiled conjectures, and they were able to make generalizations.

Keywords: Mathematical inductive reasoning ability; Mathematics learning; Learning styles


INTRODUCTION

Mathematics is one of several subjects studied from elementary school to college (Ananda & Wandini, 2022). According to Ainin et al. (2020), many students who feel that the subject in school that is quite difficult is mathematics. This resulted in low mathematical abilities possessed by students, as a result of which students had difficulty in conducting learning in class, especially during mathematics lessons (Lestari et al., 2020).

NCTM (2000, p. 29) sets standards for mathematical skills that students must master, including connection, communication, reasoning and proof, problem solving, and representation. Based on these mathematical ability standards, one of the abilities that students must master in learning mathematics is the ability to reason mathematically. This is stated in the objectives of learning mathematics at school, namely developing the ability to reason and think in making a conclusion, solving problems, and improving communication skills in conveying ideas owned by students, both through writing and oral (Kuswardani & Arcana, 2017).

Rosita (2014) argues that reasoning is a process, activity, and thought to compile new statements or draw conclusions based on statements that have been proven true. Reasoning is also needed as a basic ability to improve mathematical abilities in general (Sukirwan et al., 2018). In other words, mathematical reasoning can be said to be the process of drawing
conclusions from mathematical information that has been proven to be true. Globally, there are two types of mathematical reasoning, among them inductive reasoning and deductive reasoning (Sumarmo, 2013). According to Theresia & Nike (2015) inductive reasoning is a thinking activity in drawing general conclusions from specific things that are known to be true. Meanwhile, deductive reasoning is the process of drawing conclusions from general things to specific things (Theresia & Nike, 2015).

In the process of learning mathematics students can use an inductive mindset, although in the end students are needed to be able to think deductively. According to Khoerunnisa et al. (2020), one of the several mathematical abilities that students need and important to have in learning mathematics is the ability of mathematical inductive reasoning, because inductive reasoning serves to solve problems so that students' mathematical inductive reasoning also needs to be improved. Some inductive reasoning activities according to Sumarmo (2014), including transductive reasoning, which is drawing conclusions from a special property applied to other special cases; draw conclusions based on the similarity of processes (analogies); use relationship patterns to construct conjectures and analyze situations; provide explanations to existing models or relationships; estimate the process of solutions or answers; and generalizing reasoning, that is, drawing general conclusions based on a number of observed data.

The mathematical reasoning ability mastered by each student certainly varies. This is due to differences in the characteristics of each individual, one of which is learning style. One of the ways and strategies for every student to obtain good learning outcomes is called learning style. A person's learning style is also a combination of learning related to organizing, absorbing, and processing information (Maftuh, 2020; Sari, 2014). According to de Porter dan Hernacki (2010), learning styles are classified into three parts, namely, auditorial, kinesthetic, and visual learning styles. The learning style that tends to utilize vision is visual. The learning style that tends to utilize hearing is called auditorial. Meanwhile, learning styles that tend to utilize touch or movement are kinesthetic.

There is an influence between learning styles and mathematical inductive reasoning abilities possessed by students (Sumaeni et al., 2020). According to de Porter dan Herncaki (2010) mathematical inductive reasoning, visual students will be aroused if they see problems displayed in the form of pictures, or visual students can use images as an aid in solving a problem. In addition, de Porter dan Herncaki (2010) also argue that the mathematical inductive reasoning of auditorial students will be stimulated if they listen to something directly, for example when the teacher explains a material in front of the class, because auditorial students will hear and grasp what the teacher conveys well. While mathematical inductive reasoning in kinesthetic students will be stimulated if students perform movements and practice (de Porter & Hernacki, 2010). Therefore, it can be said that learning style is one form of developing students' mathematical inductive reasoning.

In research conducted by Haryono dan Tanujaya (2018), students of visual learning style tend to have better mathematical inductive reasoning skills compared to mathematical inductive reasoning skills of kinesthetic or auditorial learning style students. In line with that, in the research of Sayuri et al. (2020), the best learning style with mathematical reasoning ability on indicators determining the pattern or nature of mathematical symptoms in making generalizations is the visual learning style. Meanwhile, in the research of Khoerunnisa et al. (2020), learning styles capable in all indicators of mathematical inductive reasoning ability are mastery learning and self-expressive learning styles.

From the results of several previous studies, what distinguishes this research is that it is found in the subject of research, namely at the high school level and focuses research on mathematical inductive reasoning with indicators of transductive reasoning, analogies, using relationship patterns to analyze situations and construct conjectures and estimate answers or solution processes, provide explanations to existing models, facts, relationships, or data, and generalized reasoning seen from visual, auditorial, and kinesthetic learning styles.
Based on the explanation above, this study aims to describe students' mathematical inductive reasoning abilities in terms of auditorial, kinesthetic, and visual learning styles in the Sequence and Series at SMA Negeri 1 Kota Serang.

METHOD

This research uses a type of descriptive research with a qualitative approach. The subjects involved were students of class XI MIPA SMA Negeri 1 Kota Serang. Before the study, an interview was conducted first with the mathematics teacher of class XI MIPA to determine the subject of the study. From the results of the interview, a class recommendation was obtained that was used as a research subject, namely class XI MIPA-2 with a total of 34 students. This selection is based on classes with diverse learning styles and have more outstanding mathematical abilities than students in other classes. To see the learning style of each student, a learning style questionnaire was filled out. After that, researchers selected six students, two auditorial students, two kinesthetic students, and two visual students using purposive sampling techniques. The six students were given a mathematical inductive reasoning ability test and conducted deeper interviews.

The instruments used include mathematical inductive reasoning ability tests, learning style questionnaires, and interview guidelines. The learning style questionnaire used is a learning style questionnaire developed by Victoria Chislett and Alan Chapman in 2005, consisting of 30 points of statements (Nizaruddin et al., 2020). As for the indicators of mathematical inductive reasoning ability tests, among others, (1) transductive reasoning, (2) analogy reasoning, (3) using relationship patterns to compile conjectures and analyze situations and estimate the process of solutions or answers, (4) provide explanations to existing facts, models, data, or relationships, and (5) generalization reasoning. The data analysis technique used is qualitative descriptive data analysis which includes data reduction, data presentation, and conclusions.

RESULTS AND DISCUSSION

In the research process, grade XI MIPA-2 students were given a learning style questionnaire to classify students into visual, auditory, or kinesthetic learning style groups. This learning style questionnaire is given twice at different times through Google Form. This is done to see the suitability of students' answers in filling out learning style questionnaires. The following are the results of classifying the learning styles of XI MIPA-2 students.

Table 1. Learning Style Classification Results

<table>
<thead>
<tr>
<th>Learning Style</th>
<th>Number of Students</th>
<th>Part I</th>
<th>Part II</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td>14</td>
<td>14</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Auditory</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Kinesthetic</td>
<td>14</td>
<td>13</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Based on Table 1, in the first part of the learning style classification, 14 visual students, 6 auditorial students, and 14 kinesthetic students were obtained, with a total of 34 students filling out the first part of the learning style questionnaire. While the second part of the learning style questionnaire, only filled by 32 students and obtained 14 visual students, 5 auditorial students, and 13 kinesthetic students.

From the acquisition of the two learning style questionnaires that have been filled out by students, it is seen that those who filled out both parts of the questionnaire there were 29 students. By looking at the approaching scores and the consistency of students' answers, it can be concluded that the results of classifying the learning styles of grade XI MIPA-2 students are 12 visual students, 7 auditorial students, and 10 kinesthetic students. This is in line with the research of Rismen et al. (2022), where the most learning styles are visual learning styles.
After conducting mathematical inductive reasoning ability tests and interviews, the researcher analyzed the results so that they could provide a description of the mathematical inductive reasoning ability of visual, auditorial, and kinesthetic students as follows.

**Description of Visual Students’ Mathematical Inductive Reasoning Abilities**

For students with visual learning style, the transductive reasoning indicator problem is able to use transductive reasoning as in **Figure 1**.

![Figure 1](image1.png)

**Figure 1.** Visual student transductive reasoning indicator's answers

From **Figure 1**, in transductive reasoning, visual students first write down what is known, but do not write down the differences of each pattern. Because on the problem with transductive indicators presented a picture of a pattern, students visually focus on the given image pattern. In harmony with the research of Marifah et al. (2020), where visual students usually express their ideas by making pictures to solve existing problems. From the pattern of the picture, students can visually apply the properties of the square pattern to apply to the requested pattern. Thus, visual students can perform transductive reasoning by applying square patterns to obtain a pattern, but not writing down the differences in each pattern.

![Figure 2](image2.png)

**Figure 2.** Visual student analogy reasoning indicator's answers

In analogous reasoning in **Figure 2**, students visually write down what is known on the problem. Because in the problem with the analogy indicator, a picture of a pile of black and white circles is presented, visual students only count black circles because what is asked is a black circle. Based on this pattern, visual students draw conclusions related to black circles based on the similarity of processes in arithmetic rows with certain differences, so that visual students are able to apply analogous reasoning. This is in line with research of Putri dan Masriyah (2022), where visual students have analogy skills in the high category.
Figure 3. Visual student using relationship patterns to construct guesses and analyze situations and estimate solution processes indicator’s answers

In Figure 3, in using relationship patterns to construct conjectures and analyze situations, students are visually able to translate ordinary sentences into mathematical form in a clear and structured manner. This is in line with the opinion of de Porter dan Hernacki (2010), that the visual characteristics of students are thorough, structured, and neat. In the problem with this indicator, visual students use the pattern of relationships between the arithmetic sequence and the average value of the terms in the arithmetic sequence to analyze the situation and make conjectures for what is obtained. In addition, in estimating answers or solution processes, visual students use previously obtained guesses to estimate the process of finding answers or solutions, so that the answers given by visual students are correct. Therefore, visual students are able to use patterns of relationships between arithmetic sequences and other materials to construct conjectures and can predict answers or processes to get solutions correctly, even if there are steps that are missed.

Figure 4. Visual student explain facts indicator’s answers

In giving an explanation of facts, models, data, or existing relationships, it can be seen in Figure 4 that visual students explain the patterns obtained from the series presented, starting from the type of series, elements and values, and changes in the pattern of the series, although the explanation given is less detailed. This is reinforced by the opinion of de Porter dan Hernacki (2010) that visual students usually understand what will be said, but have difficulty in determining words. In addition, visual students also solve the requested problems appropriately. Thus, visual students are able to explain the nature of the patterns presented.
Figure 5. Visual student generalization reasoning indicator’s answers

In Figure 5, in generalizing, students visually identify in advance the observed data related to geometric rows. To draw general conclusions, students visually write down the possibilities that occur from the sequence asked, but not completely. From what has been obtained before, visual students draw general conclusions using a number of data that have been observed. Therefore, visual students generalize by drawing general conclusions based on the data obtained, but the data obtained is incomplete, so the conclusions drawn are also less strong even though the answers are correct. This is contrary to the research conducted by Jaenudin et al. (2017), where visual students do not provide generalizations as well as reasons for the answers given.

Description of Mathematical Inductive Reasoning Abilities of Auditorial Students

For auditorial learning style students, the transductive reasoning indicator problem is able to use transductive reasoning as shown in Figure 6.

Figure 6. Auditorial student transductive reasoning indicator’s answers

From Figure 6, in transductive reasoning auditorial students first record what is known in the problem. Because in problems with transductive indicators, images of a pattern are presented, auditorial students do not focus too much on the images given, but auditorial
students immediately write down numbers. This is in line with contention of de Porter dan Hernacki (2010), that kinesthetic students pay less attention to work involving drawings. From the numbers written on each of these patterns, auditory students apply the properties of the multilevel number pattern to apply to the requested pattern. Thus, auditorial students are able to perform transductive reasoning by applying the properties of multilevel row patterns to obtain a pattern without drawing the pattern.

Figure 7. Auditorial student analogy reasoning indicator’s answers

In analogous reasoning, presented in Figure 7 the auditorial student writes down the known on the problem. Because in the problem with the analogy indicator, a picture of a pile of black and white circles is presented, auditorial students only count black circles because what is asked is a black circle. From this pattern, auditorial students draw conclusions related to black circles based on the similarity of processes in arithmetic rows with certain differences, so that auditorial students are able to apply analogous reasoning. The statement is in line with research of Putri & Masriyah (2022), that auditorial students have high analogy reasoning skills.

Figure 8. Auditorial student using relationship patterns to construct guesses and analyze situations and estimate the solution process indicator’s answers

In Figure 8, in using relationship patterns to construct conjectures and analyze situations, auditorial students are able to translate ordinary sentences into mathematical form, but in presenting the answers are still less clear and incomplete. This is because auditorial students find it difficult to write, even though when explaining clearly and completely (de Porter & Hernacki, 2010). In the problem with this indicator, auditorial students use the pattern of relationships between the arithmetic sequence and the average value of the terms in the arithmetic sequence to analyze the situation and make conjectures for what is obtained. In addition, in estimating the solution process, auditorial students use previously obtained guesses to estimate the process of finding answers or solutions, so that the answers given by auditorial students are correct. Therefore, auditorial students can use the pattern of relationships between arithmetic rows and other materials to make conjectures and can predict answers or processes to get the right solution, even if there is incomplete writing.
Figure 9. Auditorial student explain facts indicator’s answers

In explaining the facts, models, data, or relationships presented in Figure 9, auditory students explain patterns obtained from series that are presented completely, but unstructured. The explanations given by auditorial students are presented at length, where explaining widely and clearly are the characteristics of auditorial people (de Porter & Hernacki, 2010). Thus, auditorial students are able to explain the nature of the patterns presented, but the problems given are answered incorrectly.

Figure 10. Auditorial student generalizing reasoning indicator’s answers

In Figure 10, in generalizing, the auditory student identifies the sequence in question by writing down its possibilities without elaborating on what he knows first. From what has been obtained, auditorial students draw general conclusions using a number of data that have been observed. Therefore, auditorial students generalize by drawing general conclusions based on the data obtained, but the data is incomplete, so the conclusions drawn are also less strong, even though the answer is correct. This is in line with the results of research by Jaenudin et al.
(2017), that auditory students can generalize and write down the correct final answer, but not write down the reasons for the answers obtained.

**Description of Mathematical Inductive Reasoning Abilities of Kinesthetic Students**

For students with kinesthetic learning style, the transductive reasoning indicator problem is able to use transductive reasoning as in **Figure 11**.

![Figure 11](image1.png)

**Figure 11.** Kinesthetic student transductive reasoning indicator’s answers

From **Figure 11**, in transductive reasoning, kinesthetic students write down what is known and immediately write it down in the form of a line. From these sequences, kinesthetic students can apply the properties of the stratified arithmetic row pattern to apply to the requested pattern without drawing the pattern, because it is easy to remember something seen is a visual student feature, not kinesthetic (de Porter & Hernacki, 2010). Thus, kinesthetic students are able to perform transductive reasoning by applying the properties of stratified arithmetic sequences to obtain a pattern.

![Figure 12](image2.png)

**Figure 12.** Kinesthetic student analogy reasoning indicator’s answers

In analogous reasoning, in **Figure 12** the kinesthetic student writes down the known on the problem. Because in the problem with the analogy indicator, a picture of a pile of black and white circles is presented, kinesthetic students only count black circles because what is asked is a black circle. From this pattern, kinesthetic students draw conclusions related to black circles based on the similarity of processes in arithmetic rows with certain differences, so that kinesthetic students are able to apply analogous reasoning. This is in accordance with the research of Putri dan Masriyah (2022), that kinesthetic students are able to make inferences.
In Figure 13, in using relationship patterns to construct conjectures and analyze situations, kinesthetic students are able to translate ordinary sentences into mathematical form. In the problem with this indicator, kinesthetic students use the pattern of relationships between the arithmetic sequence and the average value of the terms in the arithmetic sequence to analyze the situation and make conjectures for what is obtained. In addition, in estimating answers, kinesthetic students use previously obtained guesses to estimate the process of finding answers or solutions. However, the purpose asked by the question cannot be answered correctly by kinesthetic students and there is incomplete writing. In fact, in estimating the process to get a solution, kinesthetic students are good and write down step by step clearly. This is in line with the results of Nurul’s research in Nurdalilah (2021), that kinesthetic students tend to be hasty and less careful in counting. Therefore, kinesthetic students can be said to be able to use relationship patterns and construct conjectures, but are less able to predict answers, so the results obtained are also less precise.

In giving an explanation of facts, models, data, or existing relationships, it can be seen in Figure 14 kinesthetic students give an explanation of the patterns obtained from the series.
presented, but are less complete. This contradicts the research of Jaenudin et al. (2017), where kinesthetic students explain in detail the interpretation of the problem. In addition, kinesthetic students also provide answers to problems appropriately. Thus, kinesthetic students give an explanation of the nature of the pattern presented, although it is less complete.

In Figure 15, in generalizing, kinesthetic students first identify the observed data related to geometric rows. To draw general conclusions, kinesthetic students write down the possibilities that occur from the line asked, but there are few errors in writing. From what has been obtained before, kinesthetic students draw conclusions using a number of data that have been observed. Therefore, kinesthetic students are able to make generalizing reasoning, even if there are writing errors. This is in line with the research of Sistasari et al. (2022), where kinesthetic students are able to draw conclusions and determine the correctness of answers well. To make it easier to find out the mathematical inductive reasoning ability that each learning style has, consider Table 2.

**Table 2. Results of Mathematical Inductive Reasoning Ability**

<table>
<thead>
<tr>
<th>No</th>
<th>Indicator</th>
<th>Learning Style</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Visual</td>
</tr>
<tr>
<td>1</td>
<td>Transductive reasoning</td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td>Analogous reasoning</td>
<td>✓</td>
</tr>
<tr>
<td>3</td>
<td>Use relationship patterns to construct conjectures and analyze situations and estimate the process of solutions or answers</td>
<td>✓</td>
</tr>
<tr>
<td>4</td>
<td>Explain facts, models, data, or relationships</td>
<td>✓</td>
</tr>
<tr>
<td>5</td>
<td>Generalized reasoning</td>
<td>-</td>
</tr>
</tbody>
</table>

**CONCLUSION**

Based on the results of research that has been done, visual learning style students are able to carry out transductive reasoning; analogous reasoning; use relationship patterns to construct conjectures and analyze situations and be able to predict the process of solutions or
answers; and able to provide explanations to facts, models, data, or existing relationships. Students with auditory learning styles are able to perform transductive reasoning; analogical reasoning; and able to generalize patterns to construct conjectures and analyze situations; and able to predict the process of solutions or answers; and able to provide explanations to facts, models, data, or existing relationships. Meanwhile, students with kinesthetic learning styles are able to do transductive reasoning; analogical reasoning; and use relationship patterns to construct conjectures and analyze situations; and able to generalize.

REFERENCES


