The influence of learning styles on students’ mathematical critical thinking skills in solving trigonometric problems

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Abstract. The purpose of this study was to determine the effect of student learning styles on the ability to think critically mathematically in solving trigonometric problems. The target population for this ex post facto study is 27 students of class X MIPA at MAN 1 Sumedang school. The results showed that there was no influence of learning styles on students’ mathematical critical thinking abilities in this study. There is no difference in the ability to think critically mathematically between students who have a visual learning style with auditory, visual with kinesthetic, and auditory with kinesthetic. This finding has implications for teachers. Teachers need to focus attentively on strategies that target students with visual, auditory, and kinesthetic learning styles. By gaining a better understanding of student learning style groups, it is possible that strategies, methods, approaches, and teaching techniques that can be used to assist in the development of mathematical critical thinking skills and other important abilities can be identified and improved.

1. Introduction

The process of learning mathematics that optimizes all of the students’ abilities in the learning process becomes the attention of the world of mathematics education nowadays [1]. Learning mathematics in the 21st century emphasizes the importance of development in 4 aspects (4C), namely; Communication, Collaboration, Critical Thinking and Problem Solving, Creativity and Innovation. The ability to think critically is one important aspect that is needed by students in the learning process, especially to help solve problems that are not routine. Furthermore, learning critical thinking skills can help students build other skills, such as high-level concentration and increase the ability to analyze deeper [2]. One of the mathematical material that requires critical thinking skills is trigonometry. The results of the 2017/2018 school year national examination showed the percentage of correct answers on trigonometric material nationally was 38.99% and 22.16% for the Sumedang District level. From the results of informal interviews conducted by researchers on several high school students in Sumedang Regency stated that the number of formulas that must be memorized is not possible, so that led to reluctance to study the material further. At the national exam students are involved in cognitive processes to solve problems. Low ability to solve problems shows that students' critical thinking skills are still low. This is because the ability of mathematical reasoning, conceptual understanding, and mastery of strategies for solving problems are important aspects involved in critical thinking skills [3].

One important factor that has an impact on students’ mathematical critical thinking skills is the learning process. The teacher as a facilitator must be able to develop students’ understanding of the
material being taught and assist them in developing their skills so that they can become wise and independent problem solvers [4]. When developing the ability to think critically mathematically, each teacher is confronted with students who have different characteristics between one individual with another, thus affecting the absorption of subject matter. Most students fail to understand the lesson because they do not know how to do in learning [5]. In order to provide the best way of learning for each individual, learning styles must be known in advance by considering several differences, including: perception, personality, abilities, and intelligence [6]. Learning styles consist of three types, namely: learning by seeing (visual learning), learning by listening (auditory learning), and learning by doing (kinesthetic learning) [7]. Based on the description that has been described, further studies are needed to determine this relationship. By gaining a better understanding of the influence of learning styles on mathematical critical thinking abilities, educators can become better equipped to assist students in developing these skills.

2. Method
The research method used is ex post facto. The population of this research is the students of class X MAN 1 Sumedang, with the subject of research is 27 students majoring in Mathematics and Natural Sciences. This study aims to determine the effect of learning styles on students' mathematical critical thinking skills (MCTS) on trigonometric material. This influence can be known by giving MCTS test with trigonometric material. The test given is a written test in the form of a description consisting of 5 numbers with a maximum ideal score of 20. The test questions used refer to indicators of critical thinking ability according to Ennis consisting of five aspects which include: providing simple explanations, building basic skills, concluding, building further explanation, and determine the strategy and tactics [8].

To obtain information about learning styles from the subject of the study, a learning style questionnaire was given. This questionnaire contained 30 statements adapted from Mayaningtias [9], with reference to the learning styles and indicators according to DePorter and Hernacki which consisted of visual, auditory, and kinesthetic learning styles. Each statement has three options that indicate a certain learning style. The highest learning style score is the learning style of students.

3. Result and Discussion
The purpose of this study is to describe students' learning styles and mathematical critical thinking skills. The results of the learning style questionnaire data processing are presented in Figure 1.

Figure 1. Recapitulation of student learning style data

Figure 1 shows the percentage of the number of students classified into the type of visual learning style is 44% (12 students), the percentage of many students who are classified into the type of auditory learning style is 37% (10 students), and the percentage of the number of students who are classified into types kinesthetic learning style is 19% (5 students). Although most students absorb information visually
and auditory, but almost all students have one of the dominant senses as a tool to communicate and obtain information, so that they have a tendency towards one of the learning styles [10].

To determine the effect of learning styles on mathematical critical thinking skills (CBC), a CBC test was performed for trigonometric material. Recapitulation of student CBDM test results data based on learning style categories including minimum scores, maximum scores, average and standard deviations is presented in Table 1.

Table 1. Recapitulation of MCTS test results

| Learning Style | f | Score | Mean | Standard Deviation |
|----------------|---|-------|------|-------------------|
|                |   | Min   | Max  |                   |
| Visual         | 12| 40    | 85   | 73.33             |
|                |   |       |      | 2.60              |
| Auditory       | 10| 40    | 80   | 68.00             |
|                |   |       |      | 3.27              |
| Kinesthetic    | 5 | 55    | 80   | 70.00             |
|                |   |       |      | 2.34              |

Table 1 shows that the mean MCTS test score of students with a visual learning style gained 73.33 with a standard deviation of 2.60; auditory learning style 68.00 with a standard deviation of 3.27; and kinesthetic learning styles of 70.00 with a standard deviation of 2.34. The average MCTS scores of students based on successive learning styles are visual, kinesthetic, and auditory learning styles.

The description of the student's MCTS in general has not been tested whether there is an influence of learning styles on students' mathematical critical thinking abilities. To determine a significant difference, a different test was performed between groups.

Testing hypothesis:
H₀: There is no influence of learning styles on students' mathematical critical thinking abilities.
Hₐ: There is an influence of learning styles on students' mathematical critical thinking abilities.

Test results with a significance level of 5% are presented in Table 2.

Table 2. The test results of students' MCTM influence are based on learning style categories

| Ranks            | Learning Style | N  | Mean Rank |
|------------------|----------------|----|-----------|
| Score            | Visual         | 12 | 15.13     |
|                  | Auditory       | 10 | 13.10     |
|                  | Kinesthetic    | 5  | 13.10     |
|                  | Total          | 27 |           |

Test Statistics
Kruskal-Wallis H 0.466
df 2
Asymp. Sig. 0.792

Table 2 shows the P Value of 0.792> significance level of the study (0.05) which means the null hypothesis failed to be rejected. So, there is no influence of learning styles on students' mathematical critical thinking abilities.

To find out the differences between which learning styles are different, a Post Hoc test is performed to test the mean difference between visual and auditory learning styles, visual with kinesthetic, and auditory with kinesthetic which are presented in Table 3, Table 4, and Table 5.
Table 3. Test the comparison of mean between visual learning styles and auditory learning styles

| Ranks     | LearningStyle | N  | Mean Rank | Sum of Ranks |
|-----------|---------------|----|-----------|--------------|
| Score     | Visual        | 12 | 12.21     | 146.50       |
|           | Auditory      | 10 | 10.65     | 106.50       |
| Total     |               | 22 |           |              |

Test Statistics

| Score         | Mann-Whitney U | 51.500 |
|---------------|----------------|--------|
|               | Wilcoxon W     | 106.500|
|               | Z              | -0.581 |
|               | Asymp. Sig. (2-tailed) | 0.561 |
|               | Exact Sig. [2*(1-tailed Sig.)] | 0.582 |

a. Grouping Variable: Learning Style
b. Not corrected for ties.

Table 3 shows the P Value value of 0.561> the level of research significance (0.05) which means there is no significant difference in students' mathematical critical thinking abilities between visual learning styles and auditory learning styles.

Table 4. Test the comparison of mean between visual learning styles with kinesthetic

| Ranks     | LearningStyle | N  | Mean Rank | Sum of Ranks |
|-----------|---------------|----|-----------|--------------|
| Score     | Visual        | 12 | 9.42      | 113.00       |
|           | Kinesthetic   | 5  | 8.00      | 40.00        |
| Total     |               | 17 |           |              |

Test Statistics

| Score         | Mann-Whitney U | 25.000 |
|---------------|----------------|--------|
|               | Wilcoxon W     | 40.000 |
|               | Z              | -0.546 |
|               | Asymp. Sig. (2-tailed) | 0.585 |
|               | Exact Sig. [2*(1-tailed Sig.)] | 0.646 |

a. Grouping Variable: Learning Style
b. Not corrected for ties.

Table 4 shows the value of P Value of 0.585> the level of significance of the study (0.05) which means there is no significant difference in students' mathematical critical thinking skills between visual learning styles and kinesthetic learning styles.
Table 5. Test the comparison of mean between auditory learning styles with kinesthetic learning styles

| Ranks       | Learning Style | N  | Mean Rank | Sum of Ranks |
|-------------|----------------|----|-----------|--------------|
| Score       | Auditory       | 10 | 7.95      | 79.50        |
|             | Kinesthetic    | 5  | 8.10      | 40.50        |
| Total       |                | 15 |           |              |

**Test Statistics**

| Score       | Mann-Whitney U | Wilcoxon W | Z           | Asym. Sig. (2-tailed) | Exact Sig. [2*(1-tailed Sig.)] |
|-------------|----------------|------------|-------------|----------------------|-------------------------------|
|             | 24.500         | 79.500     | -0.065      | 0.948                | 0.953b                       |

a. Grouping Variable: Learning Style
b. Not corrected for ties.

Table 5 shows the P Value value of 0.948> research significance level (0.05) which means there is no significant difference in students' critical mathematical thinking skills between auditory learning styles with kinesthetic learning styles.

From the results of statistical tests show there is no influence of learning styles on students' mathematical critical thinking skills. If the criterion aspects of mathematical critical thinking are in line with the individual's way of absorbing and processing information, then the ability of students in these aspects will be good. There is no difference in students' MCTS if the learning process is able to accommodate each student's learning style. According to Slavin [12], effective teaching to improve critical thinking skills depends on class determination that encourages acceptance of different points of view and free discussion. Students with a visual learning style will more easily understand the material by looking, looking at, or observing the object being studied to focus attention and concentration on the learning material [13]. Giving questions from the teacher as well as questions and answers through discussion can increase the interest of auditory learners [5]. In addition, the presence of group interaction can facilitate kinesthetic learners who prefer to do direct activities and interact [5].

Each learning style has advantages and disadvantages in each aspect of mathematical critical thinking skills. Each learning style group has a different way of absorbing and processing the information received. Likewise with aspects of critical thinking skills, each aspect has its own criteria for the problem. Indicators of the MCTS test trigonometry provided include: provide simple explanations, build basic skills, conclude, build further explanations, and determine strategies and tactics. Based on Table 1, the group of students with visual learning styles had the highest average score of 73.333, compared to the average scores of auditory learning styles (68,000) and kinesthetic (70,000). This finding is different from the results of Karim's research [14] which shows that the mathematical critical thinking ability of junior high school students with kinesthetic learning styles is higher than the mathematical critical thinking ability of students possessed auditory and visual learning styles.

Paul and Elder [15] state that critical thinking skills primarily include the ability to think logically and reflect information that is known. The ability to think critically can be improved by examining and criticizing one's reasoning processes [16]. Students with auditory learning styles are able to dig out relevant information or knowledge from problems so that they can help them solve problems and are able to determine ideas that will be used to solve problems but have not been able to express ideas to solve problems optimally so students have not been able to evaluate their ideas properly. Students with auditory learning styles have difficulty while following learning which involves more formulas and calculations [17]. Whereas students with kinesthetic learning styles in the process of critical thinking are
able to mention all possible ways and the right answers that can be used so that in solving problems properly [18]. Whereas the type of visual learner is able to express his ideas neatly and orderly according to the knowledge he has and the information he gets so that students are able to solve and answer problems very well [5]. They can analyze information and design pieces of information. Students with a visual learning style are able to solve higher-order thinking problems with appropriate completion steps [19]. If true, then students with visual learning styles have greater skills in critical thinking.

4. Conclusion
Based on the results of research and discussion it can be concluded that there is no influence of learning styles on students’ mathematical critical thinking abilities. There is no difference in students’ learning styles visually with auditory, visual with kinesthetic, and auditory with kinesthetic. From the results of the average difference in student scores is not too far away, it can be said there is no learning style that dominates in the ability to think critically mathematically. Teachers may need to focus attentively on strategies that target students with visual, auditory, and kinesthetic learning styles. By gaining a better understanding of student learning style groups, it is possible that strategies, methods, approaches, and teaching techniques that can be used to help develop mathematical critical thinking skills and other important abilities can be identified and improved. Further research is needed based on the results of this study.

5. Acknowledgments
In this study the authors get a lot of help from various parties. The author would like to thank Mr. Abdul Haris M.Ag. as the principal of MAN 1 Sumedang who always provides motivation and guidance to the author.

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