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**COMPARISON OF LEARNING OUTCOMES AND STUDENT LEARNING STYLES: A STUDY ON TRIGONOMETRIC COMPARISON OF RIGHT TRIANGLES**

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**Abstract**

Poor knowledge of mathematical concepts leads to poor math learning outcomes among students. Good reasoning will equip students to explain and argue mathematically. Therefore, the purpose of this study is to determine the comparison of learning outcomes and learning styles of students on trigonometric comparison material in right triangles. The variables in this study are visual learning style, auditorial learning style, and kinesthetic learning style (VAK) as independent variables and math learning outcomes as dependent variables. The participants in this study amounted to 77 people who came from the tenth grade, majoring in mathematics and natural sciences. The data used in this research is quantitative. Quantitative data is data in the form of numbers obtained from the results of a questionnaire consisting of 21 questions and mathematics learning outcomes received after working on a description question with as many as 3 numbers. The data analysis technique in this study is using the Mann Whitney-U test. The results of the survey obtained 23 or 29.9% of students with visual learning styles, 41 or 53.2% of students with auditory learning styles, and 13 or 16.9% of students with kinesthetic learning styles. The average learning outcome of students with a visual learning style is 70.09, students with an auditorial learning style are 71.72, and students with a kinesthetic learning style are 69.29. Based on the results of the analysis using SPSS 26.0, the significance value of each paired group of learning styles is more than the significance level α = 0.05. Therefore, there is no difference in math learning outcomes between students whose learning styles are visual, auditory, and kinesthetic.

**Keywords:** Learning Outcomes; Learning Styles; Trigonometry



**INTRODUCTION**

Mathematics is a universal science that drives the development of modern science and technology. Mathematics has a vital role in various disciplines that have implications for the exploratory power of the human mind (Weintrop et al., 2016) At the psychological level, learning mathematics helps develop analytical thinking, composing ideas, and communicating mathematically precise views (Sachdeva & Eggen, 2021) Mathematics helps in the proper understanding of one's ideas (Algani, 2022). Achievement in Mathematics is a fundamental indicator of school system performance in any country (Wang et al., 2023). In addition, mathematics is a crucial subject for countries with developing economies, as it enables students to enroll in engineering, science, accounting, and many others essential to support economic development (Makgato & Mji, 2006) This condition is inversely proportional to the state of education. Global information comes from developing countries. For example, in South Africa, it was found that students' interest in the field of mathematical sciences still needs to be higher (Bosman & Schulze, 2018) The famous Trends in International Mathematics and Science Study (TIMSS), conducted in 2015, found that student achievement in Indonesia was poor. 27 percent of 4th-grade students still needed to meet the standard (Beatty et al., 2021).

It has been believed by various parties that mathematics has a significant contribution to the development and progress of a nation. Therefore, it is necessary to improve the quality of mathematics education in order to improve student learning outcomes. However, in the conditions in schools today, student learning outcomes are still meager (Laurens et al., 2018; Bringula et al., 2021). This is the case in Tanzania, where 70.1% of high school students failed math in the National exam. These results pave the way for further research that seeks to characterize and understand the diversity of factors that can influence student and teacher performance in mathematics. This will help to design good strategies for future improvement so as to increase the pass rate in mathematics learning (Mazana et al., 2018). It should be noted that students in each class have different abilities. Therefore, it will result in the achievement of different learning outcomes (Gamage et al., 2021). Unfortunately, in teacher-conducted learning, all students are required to learn in the same way and at the same pace (Rijken & Fraser, 2023) Low-achieving students, without sufficient time, will have difficulty being forced to receive knowledge passively (Yeh et al., 2019). Study results show that Teachers in China tend to adopt a more teacher-centered way to ensure complete and practical teaching (Lin et al., 2020). Learning outcomes are something that is obtained after the learning process. Learning outcomes are changes that occur in students concerning cognitive, affective, and psychomotor aspects (Rao, 2020).

Learning outcomes are often considered the determinant of an education. The fact is that students constantly score poorly in math, even though the subject is relatively vital to life today (Maruta, 2021). Over the years, mathematics researchers have identified factors leading to poor student performance in mathematics. Some of these include weak student grounding in mathematics, overcrowded mathematics classrooms and math resource fatigue, anxiety towards mathematics, poor teaching strategies, lack of resources for teaching and learning mathematics, unfavorable student and teacher attitudes towards mathematics, student laziness, and lack of student retention and interest in mathematics. (Egara & Mosimege, 2023). Several factors affect learning outcomes themselves, including learning styles.

A learning style is the way a person tends to receive information from the environment and process that information. Three common learning styles are often used and have been divided into three subtypes of learning styles: visual, audio, and kinesthetic (Gamboa Mora et al., 2021). Dunn and Dunn in Gilakjani (2011) stated that only about 20-30% of school-age children fall into the auditory learning style type, 40% are students with visual learning styles, and 30-40% as kinesthetic or visual learners/tactics (Dunn, 1983). In addition, the results of research to identify VAK learning styles in Sohar students in Oman showed that 36% were visual, 35% auditory, and 29% kinesthetic (Hamdani, 2015). Furthermore, research conducted by (Leasa et al. 2018) stated that 88.7% of students used a learning style (unimodal), and 11.3% of students combined more than one learning style (multimodal). For unimodal learning styles, kinesthetic is most prevalent in male and female students, with a percentage of 58.6%, while visual is least found, with a rate of 6%.

Good cognitive skills are critical in student mathematics learning, which can help in understanding and mastering mathematical concepts (Wan Hussin & Mohd Matore, 2023) The VAK learning style is more well-known and easy to use in identifying a person's learning style (Jamil et al., 2015). One of the most popular learning style theories is Fleming & Mills' (1992) VARK model (visual, aural, reading/writing, kinesthetic). It has been modified from the VAK model by adding R by Fleming & Baume (2006) because he believes that although learners can be visual, they may learn better by reading written forms rather than pictures or symbols. Learners can be multimodal by having two or more modes develop equally. Thus, learning styles can help students understand math concepts more effectively (Cuevas, 2015). In addition, they create a more enjoyable mathematics learning atmosphere because it is more interactive (Nancekivell et al., 2020).

The characteristics of students' learning styles can be seen during math learning. Students with a visual learning style learn mathematical concepts through images, such as by describing formulas (Caligaris et al., 2015). For example, on the topic of geometry, students with visual learning styles analyze geometric shapes through photographs. Meanwhile, students with auditory learning styles listen to the teacher's explanation of the math topic being studied (Zales & Vasquez, 2022), and they constantly repeat math concepts, such as saying math formulas regularly so that they can remember formulas better. Kinesthetic learning style practices often apply math topics in daily life. For example, on the subject of algebra, students are given real situations to form algebraic expressions (Ganesen et al., 2020). Therefore, with an effective learning style, students can master math concepts more quickly and easily (Mangwende & Maharaj, 2020)

When students can understand mathematical concepts and content effectively, they can complete the tasks given by the teacher very well without procrastinating (Ingram et al., 2019). However, due to a lack of mathematical understanding, students are not interested in math tasks. Therefore, they cannot re-explain concepts or apply them to solve math problems (Adeleke, 2007). Students also need help connecting newly learned mathematical concepts with other mathematical concepts (Hsiao et al., 2018). Most students only memorize formulas and steps for solving mathematical problems without understanding them. This causes students to need help solving math problems or exercises (Malepa-Qhobela & Mosimege, 2022) Therefore, the right learning style can create a positive atmosphere when learning math (Hu et al., 2021) and further reduce students' tendency to engage in academic procrastination in mathematics (ÖZKAYA et al., 2022)

In a study on academic procrastination involving students in Indonesia, late submission of Math assignments was most prominent (44%), followed by Physics (31%) and other subjects (28%) (Setiyowati et al., 2020). Mathematics education in Malaysia involves a lot of practice to strengthen students' understanding of mathematical concepts (Md-Ali & Veloo, 2021) The goal is to produce a Malaysian workforce that is well-trained, brilliant thinkers, creative, innovative, competitive, multi-skilled, enterprising, confident, able to master and utilize the latest digital technology, and continuous learners (Tarmizi & Tarmizi, 2010). Teachers usually give assignments or math exercises in textbooks or reference books as homework so that problem-solving skills and mathematical theories and concepts can be honed and improved (Chamberlin, 2010). These math assignments or exercises will then be discussed in the next class, and students may also need to complete them before class. Therefore, the suitability of students' learning styles plays a role in encouraging them to be thorough in math tasks (Fernández-Alonso et al., 2016)

It will be challenging for someone to concentrate on learning if they feel forced. Therefore, there needs to be a way to make learning math fun. The teacher's role is to provide space for students to make mathematical connections, ask questions, develop their argumentation skills, and articulate their reasoning. Students with good reasoning skills will be equipped with the accuracy and appropriateness of the language they use to explain and argue mathematically (Smit et al., 2023). By recognizing learning styles, students will be able to manage under what conditions, where, when, and how they can maximize learning. Understanding students' learning styles is very important in the teaching and learning process because by knowing the learning styles of each student, teachers can help develop the potentials that exist in students according to their abilities (Özgen et al., 2011) Education cannot be fully achieved without learning habits that match learners' knowledge that learning styles and learning habits go together not only in learning but also in helping instructors support individual students towards better learning (Garizábalo-dávila et al., 2024) Thus, the purpose of this study is to determine the comparison of learning outcomes and learning styles of students on the material of trigonometric comparison in right triangles.

**METHODOLOGY**

The type of research used in this study is an experimental class with a quantitative approach. In this study, researchers involved four variables, namely visual (𝑋1), auditorial (𝑋2), and kinesthetic (𝑋3) learning styles as independent variables. In contrast, math learning achievement was the dependent variable (Y), and then researchers tried to explain the causes of these differences. The research design can be shown in Figure 1.

Table 1. Research Design

|  |  |
| --- | --- |
| Independent variable | Dependent variable |
| X1 | Y |
| X2 |
| X3 |

The instrument used in this research is an essay form learning outcome test of 10 questions about elevation angles and depression angles. Before being given a test of student learning outcomes, students were first given a learning style questionnaire consisting of 22 statements, with details of 8 numbers for visual statements, 7 numbers for auditorial statements, and 7 numbers for kinesthetic statements. Before the learning outcomes test and learning style questionnaire are used, they must first be validated by validators (3 Pattimura University Mathematics Education Lecturers).

Research data collection was intended to record events or characteristics of some or all elements of the research population. The data used in this study are quantitative, namely data in the form of numbers obtained through a questionnaire with a total of 22 statements and mathematics learning outcomes of tenth-grade students of YPKPM Ambon Christian High School. Learning outcome data was obtained from student test results after working on questions as many as 3 numbers in essay form.

The normality test used in data analysis was the Kolmogorov-Smirnov parametric statistic. Normality test with testing criteria: if the significance level is 0.05, then it can be said that the data is usually distributed. The homogeneity test was carried out as a basis for determining whether the prices of variants in the group are homogeneous or relatively similar. The calculation of homogeneity of variant prices was carried out at the beginning of data analysis activities. This was done to ascertain whether the assumption of homogeneity in each data category has been fulfilled or not. If the homogeneity assumption was proven, it could be done at the advanced data analysis stage. If it had not been fulfilled, the Barlett Test can be used.

Hypothesis, according to K Dayanand (2020), is a temporary answer to the formulation of research problems, where the formulation of research problems has been stated in the form of a statement sentence. Therefore, the researcher formulates a hypothesis in each group of visual, auditorial, and kinesthetic learning styles as follows. 𝐻0: there is no significant difference in learning outcomes of trigonometric comparison in right triangles before and after the test. 𝐻1: there is a substantial difference in learning outcomes of trigonometric comparison in right triangles before and after the test. The basis for decision making: Ho is accepted, and H1 is rejected, or Sig .> α (α=0.05) Ho is rejected, and H1 is accepted or Sig. < α From the research conducted, the data obtained shows that the data is not normally distributed. For data that was not normally distributed, after the Kruskal-Wallis test, it was continued with the Mann-Whitney test.

To test data that is more than 2 groups, we use the Post Hoc test. The data obtained from the research showed that the data was not normally distributed. Data that is not normally distributed after the Kruskal Wallis test is continued with the Mann-Whitney test as a Post Hoc test on the Kruskal Wallis test. Researchers formulated the research hypothesis as follows. 𝐻0: there is no significant difference in learning outcomes of trigonometric comparison in right triangles in terms of visual, auditorial, and kinesthetic learning styles. 𝐻1: there is a substantial difference in learning outcomes of trigonometric comparison in right triangles in terms of visual, auditorial, and kinesthetic learning styles. Basic decision making: Ho is accepted, and H1 is rejected or Sig.> α (α=0.05) Ho is rejected, and H1 is accepted or Sig. < α.

**RESULTS AND DISCUSSION**

Bagian ini merupakan bagian utama artikel hasil penelitian dan biasanya merupakan bagian terpanjang dari suatu artikel. Hasil penelitian yang disajikan dalam bagian ini adalah hasil “bersih”. Proses analisis data seperti perhitungan statistik dan proses pengujian hipotesis tidak perlu disajikan. Hanya hasil analisis dan hasil pengujian hipotesis saja yang perlu dilaporkan. Tabel dan grafik dapat digunakan untuk memperjelas penyajian hasil penelitian secara verbal. Tabel dan grafik harus diberi komentar atau dibahas.

Based on the results of descriptive statistical data processing, the following data were obtained. 1) The average math learning outcomes of students who have a visual learning style is 70.09; 2) The average mathematics learning outcomes of students who have an auditorial learning style is 71.72; 3) The average mathematics learning outcomes of students who have a kinesthetic learning style is 69.29. Based on the results of the questionnaire distributed to 77 students of the X-MIA class, YPKPM Ambon Christian High School, the results are shown in Table 2.

# Table 2. Results of Student Grouping Based on Learning Style

|  |  |  |
| --- | --- | --- |
| **Learning Style Group** | **Number of Students** | **Percentage** |
| Visual Group | 23 | 29,9% |
| Auditorial Group | 41 | 53,2% |
| Kinesthetic Group | 13 | 16,9% |

## *Pretest and Post-test Hypothesis Test Results*

The results of the pretest and post-test hypothesis tests from each learning style group can be seen as follows.

*Prerequisite Tests of Normality and Homogeneity*

The following will present tables of pretest and post-test prerequisite test results for each learning style group.

## Table 3. Visual Learning Style Prerequisite Test Results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Results** | **Normality** | | | **Decision** |
| **Kolmogrov Smirnov** | | |
| **Statistics** | **df** | **Sig.** |
| Pretest | 0,188 | 17 | 0,111 | Normal |
| Posttest | 0,257 | 17 | 0,004 | Not normal |
|  | | | | |
| **Homogeneity** | | | | |
| **Sig** | **Levene Test** | **df1** | **df2** | **Decision** |
| 0,904 | 0,015 | 1 | 32 | Homogeneous |

From Table 3, the normality test shows that the Sig value. Pretest 0.111 > α and Posttest 0.004 < α. Therefore, the data from the Pretest is "**normally distributed"** while the data from the Post-test is "**not normally distributed** ."TheHomogeneity Test shows that the Sig. Value is 0.904 > α so that the data from the Pretest and Post-test are "**Homogeneous."**

## Table 4. Auditorial Learning Style Prerequisite Test Results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Results** | **Normality** | | | **Decision** |
| **Kolmogorov Smirnov** | | |
| **Statistics** | **df** | **Sig.** |
| Pretest | 0,16 | 32 | 0,036 | Not Normal |
| Posttest | 0,187 | 32 | 0,006 |
|  | | | | |
| **Homogeneity** | | | | |
| **Sig** | **Levene Test** | **df1** | **df2** | **Decision** |
| 0,894 | 0,18 | 1 | 62 | Homogeneous |

From the table, the normality test shows that the Sig value. Pretest 0.036 < α and Posttest 0.006 < α. The Homogeneity Test indicates that the Sig. Value is 0.894> α, so the data from the Pretest and Post-test are "Homogeneous."

## Table 5. Kinesthetic Learning Style Prerequisite Test Results

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Results** | **Normality** | | | **Decision** |
| **Kolmogrov Smirnov** | | |
| **Statistics** | **df** | **Sig.** |
| Pretest | 0,197 | 11 | 0,2 | Normal |
| Posttest | 0,168 | 11 | 0,2 |
|  | | | | |
| **Homogeneity** | | | | |
| **Sig** | **Levene Test** | **df1** | **df2** | **Decision** |
| 0,785 | 0,07 | 1 | 20 | Homogeneous |

From the table, the normality test shows that the Sig value. Pretest 0.2 > α and Post-test 0.2 > α. so that the Pretest and Post-test data are "non-normally distributed ."The Homogeneity Test shows that the Sig. Value is 0.894 > α, so the data from the Pretest and Post-test are "Homogeneous."

## *Hypothesis testing*

The following table presents the results of the hypothesis test for differences in pretest and post-test learning outcomes from each learning style group.

## Table 6. Hypothesis Test Results of Differences in Pretest and Post-test Learning Outcomes

|  |  |  |
| --- | --- | --- |
| **Learning Style Group** | **Sig.** | **Decision** |
| Visual | 0,106 | 𝐻0 |
| Auditorial | 0,468 | 𝐻0 |
| Kinesthetic | 1 | 𝐻0 |

Data Table 6 shows that the significance value of the three learning styles is less than α. Based on decision-making, H0 is accepted, so there is no significant difference in learning outcomes on trigonometric comparison material in right triangles in terms of visual, audiotorial, and kinesthetic student learning styles.

Post Hoc Test Results

Based on the results of the pretest and post-test hypothesis tests, the following table presents the results of the post hoc test of the three classes, Prerequisite Tests of Normality and Homogeneity. In the prerequisite test on the post-test using the Kolmogrov-Smirnov test, it can be seen that the results of the prerequisite test of the three learning styles are homogeneous. However, post-test data on visual and audiotorial learning styles are not normally distributed, while kinesthetic learning styles are typically distributed. For this reason, post-test data on learning styles will be tested again for normality using the Kruskal-Wallis test shown in Table 7.

Table 7. Normality Test of Post-test of the Three Learning Styles

|  |  |  |  |
| --- | --- | --- | --- |
| **Kruskal Wallis- H** | **Df** | **Sig.** | **Decision** |
| 0,502 | 2 | 0,778 | Not Normal |

From the table above, the normality test of the three learning styles is not normally distributed.

## Post Hoc Test

In this study, it was seen that the three-post-tests data from each learning style obtained were not normally distributed. Therefore, the difference test was conducted on these three learning styles to see differences in learning outcomes using the Mann-Whitney test. The Mann-Whitney test will sort out differences between learning style groups. The difference test is shown in Table 8.

Table 8. Post-tests Difference Test of the Three Learning Styles

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Group | Learning Style | Z | Sig | Decision | Final Decision |
| 1 | Visual | -0,224 | 0,823 | 𝐻0 | 𝐻0 |
| Auditorial |
| 2 | Visual | -0,64 | 0,519 | 𝐻0 |
| Kinesthetics |
| 3 | Auditorial | -0,67 | 0,544 | 𝐻0 |
| Kinesthetics |

In the table above, all the significance values of each group are less than the significance level. The final decision shows that there is no significant difference in learning outcomes of trigonometric comparison in right triangles in terms of visual, auditorial, and kinesthetic learning styles. One of the causes of ineffective learning styles is that students need to be given sufficient exposure to learning styles at an early stage (Leasa et al., 2018). This is because students are not given specific guidance on how or what their learning style is (Leasa et al., 2017). Ineffective learning styles cause students to be less interested in Mathematics, and this will lead to unsuccessful learning because students need a sufficient basis of knowledge. This is indicated by previous findings, which convey that one of the most enduring concerns among mathematics educators in America is student improvement in mathematics performance. Since the 1960s, international comparative studies have consistently shown that students in the US lag behind students in other developed countries in math performance (Ma & Ma, 2014). The critical learning holder is the teacher to enhance the practice of different learning styles as a strategy to improve students' mathematics performance. Differences in each student's learning style require teachers to identify and adapt math teaching methods to students. One of the factors affecting students' inability to master the learning content well is the teacher's teaching style, which is not in accordance with the variety of learning styles that students have (Newton & Miah, 2017). Thus, teachers need to identify students' learning style patterns in order to plan better teaching and learning strategies based on the characteristics of each learning style (Sun et al., 2023).

Learning styles, as a single concept, are all the rage in schools today and in primary schools in England and Wales in particular. However, this is different from the learning style within educational and cognitive psychology, where learning style theory and practice are presented and debated at the highest academic level. This is the learning style called VAK. We already know that many local government advisors and head teachers are busy promoting primary school VAK. Many primary school teachers are busy administering VAK-style learning questionnaires to children and labeling them as visual, auditory, or kinesthetic learners. Most likely due to its emergence in schools, VAK has also found a place in universities and colleges, where it is introduced to students as part of their initial teacher training and education studies degree courses. To us,, the buzzwords visual (V), auditory (A), and kinesthetic (K) seem relatively commonplace, recognized by teachers, trainees, and others almost everywhere we go, and have some meaning. However, something somewhere needs to be fixed. VAK is common in primary schools, as we mentioned a moment ago, but it is not part of the 'establishment' learning style. Scratching beneath the surface of it all, we find a rather interesting world of accelerated and brain-based learning, a world of pseudoscience, psychobabble, and neuron sense, and one acknowledged, quite naively perhaps, by the Department for Education and Skills (DfES) (Sharp et al., 2008).

**CONCLUSION**

Based on the results and discussion of the research, it can be concluded that 1). Questionnaire data obtained 23 or 29.9% of students with visual learning styles, 41 or 53.2% of students with auditorial learning styles, 13 or 16.9% of students with kinesthetic learning styles; 2). The average learning outcome of students with a visual learning style is 70.09, students with an auditorial learning style are 71.72, and students with a kinesthetic learning style are 69.29; 3). There is no significant difference in learning outcomes of trigonometric comparison in right triangles in terms of visual, audiotorial, and kinesthetic learning styles. Therefore, the results of this study are expected: 1) For mathematics teachers to recognize student's learning styles, especially students with low learning outcomes; 2) For schools, it is expected to provide facilities and infrastructure that can support the success of students who have different styles of learning; 3) For researchers, to conduct broader research on learning styles, for example between one school and another.

Different learning styles of students have been identified based on their tendency to learn Mathematics. There are three main types of learning styles that students adopt in Mathematics, namely visual, auditory, and kinesthetic learning styles. Visual learning is the dominant learning style among students in mathematics, followed by acoustic and kinesthetic learning styles. The level of students' academic procrastination in Mathematics is also low. In addition, the study found that visual and kinesthetic learning styles have a significant influence on students' academic procrastination in Mathematics. Therefore, exposure to different learning styles should be enhanced through excellence in school programs to provide knowledge to students in order to enable them to identify their learning styles and effectively practice learning styles so that the quality of students' learning in Mathematics subject can be improved. Regarding the implications, this study suggests improvements in the excellence program in schools by providing exposure to students on how to identify their appropriate learning styles so that they can practice effective learning styles in Mathematics subject and overcome academic procrastination.

This study has certain limitations because it only focuses on giving questions and questionnaires on VAK learning styles for tenth-grade students in learning Mathematics. Therefore, the research findings cannot be generalized to other subjects at school. This study is also limited to one independent variable, which is students' learning style toward their academic procrastination in Mathematics. Thus, other factors that can still affect students' learning outcomes of procrastination in mathematics still need to be examined. Future research can be conducted by identifying different factors that cause academic procrastination in Mathematics in order to increase students' motivation and self-efficacy in this subject.

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